NASA CR 101964

FINAL REPORT

S-BAND POWER AMPLIFIER

IMPROVEMENT PROGRAM

9-8142

Prepared for
NASA MANNED SPACECRAFT CENTER
Houston, Texas

N69-40872	
(ACCESSION NUMBER)	(THRU)
141	1
(PAGES)	(CODE)
NASA CR # 101964	09
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

By

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

In Accordance With
Article XVIII
NAS9-8142

COLLINS RADIO COMPANY

NAS 9-8142

FINAL REPORT

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FINAL REPORT NAS 9-8142

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1.0 Scope

1.1 This report documents and summarizes the results of the efforts of Collins Radio Company pursuant to the requirements of Contract NAS 9-8142. This report, in conjunction with the equipments referenced in Article IX, shall fulfill the requirements of Article I of Contract NAS 9-8142.

2.0 Reference Information

The necessary reference information required for execution of this contract was derived from the Statement of Work, Exhibit A to NAS 9-8142, dated 29 June 1968 and all applicable documents referenced therein.

3.0 Summary of Effort

Two different types of S-Band Power Amplifiers were modified. The Apollo Block II Engineering model PP-2 was modified primarily in the RF circuitry to determine the feasibility of ferrite circulator switching. The S-Band Power Amplifier D-1 was modified in the power supply area to improve efficiency and operational characteristics.

3.1 Engineering Model PP-2, CRC P/N 514-0011-001

The engineering model PP-2 S-Band PA was modified by deleting the circuitry associated with the 5 watt mode and replacing the Transco coaxial switches with a ferrite isolator/switch assembly and its associated control circuitry. As a result of these modifications, it was necessary to replace the original component mounting board with a redesigned unit containing fewer component parts.

The ferrite isolator/switch assembly, utilized in this modification, contains six switchable ferrite circulators and two load isolators with integral loads. The assembly was designed to fit between the traveling wave tubes and to thus utilize the space previously occupied by the Transco switches and their mounting bracketry.

The form factor of the ferrite assembly necessitated a redesign of the connector/line filter housing and the relocation of the RF attenuators to provide adequate clearance between the connector/line filter housing and the top of the ferrite assembly.

The PP-2 model was rebuilt and is defined as PP-2 (modified) in this report and so marked on the name plate. During pre-ATP testing an oscillation was found to be present when all interface connectors, J2, J3, J4 and J5 were not terminated in 50 ohm loads. Further discussion on this subject is contained in Section 6. The oscillation problem was overcome by the use of a small, lightweight, coax switch, K2, in place of the input amplify/bypass circulator switch. This approach was selected because of schedule and cost considerations. Testing was continued and the final ATP data taken is presented in Section 8.

3.2 Engineering Model D-1, CRC P/N 514-1400-001

The engineering model D-1 S-Band PA was modified by removing all components and redesigning the entire layout. The new layout has the RF components mounted on the top (connector half) and the power supplies below the heat sink mounting flange. The only fabricated parts reused were the top and bottom half case shells. The original diplexer was not packaged inside allowing more room for the power supplies.

The power supplies (one for each TWT) were redesigned utilizing circuitry similar to the MOL S-Band power supplies which have operated satisfactorily when subjected to space qualification environments. Modifications to the MOL S-Band power supplies were necessary to accommodate the higher power requirements of the D-1 S-Band Power Amplifiers. The new power supplies are mirror images of each other to simplify mechanical design.

The D-1 model was modified as indicated above, and is now referred to as D-1 (modified), in this report. The ATP data taken is presented in Section 8.

3.3 Ferrite Switch Life Test

Eight ferrite (circulator) switches were subjected to a 6000 hour life test at ambient environmental conditions. The path of each switch was changed, by reversal of coil voltage polarity, at 6 minute intervals throughout the entire period of the test. The units were driven by a TWT amplifier which provided 20 watts of input power at S-Band frequencies.

Electrical measurements for insertion loss and port-to-port isolation were made prior to initiating the test and at each 1000 hours during the test period. The final data, taken at the end of the 6000 hour life test, and the interim test data taken at the end of each 1000 hours of testing, indicates no degradation of performance for the composite 48,000 component operating hours. Refer to Appendix A for the ferrite life test report.

4.0 RF Performance

The measured RF performance is compared with predicted and typical ATP data on similar equipment. The PP-2 (modified) is compared with an S-Band PA production Q model Serial Number 0010 and the predicted output power was +40 dbm for all conditions. The D-1 (modified) is compared with the original ATP on D-1 taken 3 August 1966.

4.1 S-Band PA Model PP-2 (Modified)

Table 4.1-1 is a listing of ATP RF data taken on PP-2 (modified) and Apollo Q model SN 0010 using the same test equipment. The PP-2 (modified)

Table 4.1-1

ATP RF Data Taken on PP-2 (Modified)
and Q Model 0010

		PP-2(Modified) (dbm)	Q Model SN 0010 (dbm)
PM Output Power (V1)	low drive	40.95	41.2
	mid drive	41.0	41.2
	high drive	40.9	41.05
PM Output Power (V2)	low drive	40.4	41.4
	mid drive	40.9	41.5
	high drive	40.95	41.4
FM Output Power (V1)	low drive	40.[illegible]	41.7
	mid drive	40.8	41.15
	high drive	40.65	41.0
FM Output Power (V2)	low drive	40.6	41.4
	mid drive	40.85	41.65
	high drive	40.8	41.55
PM Bypass loss		2.5 db	2.3 db
Receive loss		2.05 db	1.75 db

Drive Levels:

PM	low	23.6 dbm	FM	low	19.2 dbm
	mid.	24.7 dbm		mid	20.3 dbm
	high	25.6 dbm		high	21.2 dbm

data was taken 17 June 1969 and Q model SN 0010 data was taken 7 December 1966. The Apollo specification called for more than +40.5 dbm output power in both FM and PM modes. The data shows that PP-2 (modified) met the Apollo output power levels (+40.5 dbm) for all conditions except one, (+40.4 dbm) in PM mode using V2 and low drive. There was, however, only 0.1 db margin above the +40.5 dbm on the next lower power output in FM using V1 and low drive. It should be noted that Q model 0010 measured 0.5 db above +40.5 db output at its lowest power level. This power output level is typical of the Apollo Block II power amplifiers. The ATP data was taken at room ambient conditions.

The predicted output power was greater than +40.0 dbm under all conditions. No environmental tests were conducted on PP-2 (modified) on this contract. The measured 0.4 db margin in power output would allow the modified PA to meet the +40.0 dbm requirement under environmental conditions similar to those used in Apollo Block II qualification.

4.2 S-Band PA D-1 (Modified)

Table 4.2-1 lists the pertinent ATP data taken on D-1 and D-1 (modified). The RF circuit of D-1 was not modified but the physical layout was changed to allow the power supplies to be placed side by side below the heat sink center plate. All the RF components, including the TWT amplifiers, are mounted above the heat sink center plate. The RF components are closer together in D-1 (modified) allowing less interconnecting coax cable resulting in less loss and higher power output.

Power output of D-1 was about 41.7 dbm and power output from D-1 (modified) is approximately 42.8 dbm. The difference is partially accounted for by removal of the diplexer which has a 0.55 db insertion loss. The remainder of the improvement was achieved by a more efficient RF layout and use of better voltage regulation to the TWT.

Table 4.2-1

ATP Data Taken on D-1 (Modified) and Original D-1

		D-1 (Modified) (dbm)	D-1 (dbm)
Output Power (Amplifier 1)	low drive*	42.85	41.62***
	mid drive	42.9	41.72***
	high drive	42.6	41.67***
DC Power(Amplifier 1)		108.5 watts	122.8 watts
Output Power (Amplifier 2)	low drive*	42.65	41.67***
	mid drive	42.85	41.67***
	high drive	42.6	41.12***
DC power (Amplifier 2)**		110 watts	116.2 watts
Bypass loss		0.9 db	1.68 db ***

*Drive levels: low +24.0 dbm
mid +25.5 dbm
high +27.0 dbm

**Measured using +28.0 Vdc input at mid drive

*** Includes diplexer loss

5.0 Reliability

The reliability effort on this program consisted of the following:

1. Ferrite switch life test and test report (Appendix A).
2. Part application tests made on both power amplifiers.
3. Participation in parts selection and application.

5.1 Apollo PP-2 (Modified)

The replacement of mechanical RF switching with solid state (ferrite) switching resulted in an inherent improvement in reliability although this improvement is not numerically supportable by the out-dated failure rates for ferrite devices listed in MIL-HDBK-217A. The deletion of the 5 watt mode and associated control logic resulted in further improvement in reliability by direct reduction of the component parts count.

5.2 S-Band PA D-1 (Modified)

The reliability of the modified D-1 PA, if viewed only from the basis of component part count, has a lower reliability prediction than the unmodified unit. However, the prediction for the unmodified unit did not take into consideration the parts that were being subjected to stresses beyond their rated limits. All parts used in the modified unit have been derated per Apollo and MOL part derating requirements and the resulting improvement in reliability has been demonstrated by 1) the testing performed on the power supply developed for the MOL program during both development and prequalification testing and 2) by the operational testing performed on the breadboard of the D-1 power supply.

6.0 Modifications

6.1 Apollo PP-2 PA

The engineering model PP-2 was modified by replacing four mechanical RF switches with a single ferrite switching package and relocating most of the electrical components. The 5 watt mode components as well as the control logic circuitry were removed providing the extra space needed for the switching package.

6.1.1 RF Path Modification

The four Transco coax switches were replaced with an isolator-switch package part number 044-0052-277. The 044-0052-277 specification is presented as Appendix B to this report. The isolator-switch package was designed by E and M Laboratories and Collins Radio Company to electrically replace the Transco switches and to fit in the space provided by removing various components and mechanical parts. The physical form factor of the package is optimum for the Apollo Block II

PA configuration only, as the switch package fits between and above the traveling wave tubes. The present form factor has the center of gravity, CG, located too high for good vibration characteristics. Refer to Appendix B for outline drawings of package. This package contains six switchable ferrite circulators and two load isolators. The addition of the load isolators to this package gives protection to the traveling wave tubes that was not provided in the original Block II PA design.

During testing an oscillation at 3.3 GHz was found when no rf drive was present. A feedback path was found in the PM bypass rf circuit caused by too little isolation in the output bypass switch. The isolation problem is due to the fact that the triplexer PM input is 50 ohms (1.2:1 VSWR) only at the center frequency (2287.5 MHz $\pm$3 MHz). At other frequencies the VSWR goes up and the in-going rf or noise is reflected back and goes through the reverse bypass path to the TWT input. The phase of the feedback must be correct for oscillation to occur and is determined by the electrical length of the rf path and the reflection coefficient of the triplexer PM input as a function of frequency.

Typical Hughes 394H TWT amplifier has a saturated gain of 26 db and a maximum gain of 30 db just below saturation. The maximum gain of 30 db indicated at least 40 db of isolation should be provided for safe operation. This was verified in the lab when a variable attenuation was placed in the feedback path. Oscillations were present with 33 db isolation and stopped using 40 db isolation. The best solution to the problem would be to redesign the ferrite switch package to provide the proper isolation, however, schedule and cost considerations prohibited this approach. The fastest and least costly solution to the oscillation problem was to incorporate a small low power coax switch in the input bypass/amplify position to replace the input circulator switch. The coax switch selected was an Amphenol RF Division Type 303-10179-11 unit. This coax switch provides greater than 60 db isolation at all the frequencies that the TWT can amplify. The Amphenol switch was mounted inside the PA and is controlled by the PM amplify indicating circuitry. Refer to Section 7 for location of the added switch, K2.

6.1.2 Logic Circuit Modification

The control logic circuitry was removed along with circuits that shutdown the TWT voltage when switching the various modes of operation. The deletion of the 5 watt mode reduced the number of control components.

The control logic circuit was located on the circuit board. Removing the control components allowed space for a new board layout with better accessibility to the components for wiring and testing.

The new circuit board has a current regulator to control the dc current to the switching package at 130 ma for optimum RF characteristics.

6.1.3 Power Supply Modification

The Block II S-Band power amplifier uses a 400 Hz three phase source of power. The power supply was modified by removing the components (transformers, diodes, chokes, etc.) that were connected with the 5 watt mode. Since both traveling wave tubes had 5 watt mode power supplies, the space savings was large and allowed the switching package to fit inside the unit.

The high voltage series regulator was modified per the MOL S-Band Power Amplifier. The modification changed the series regulator transistors to a single higher voltage transistor and improved the efficiency of the regulator. The 5 watt mode components were removed allowing a simpler circuit.

The thermal time delay relays were removed and replaced with solid state timers that require less power and space. The timer circuit was adapted from the MOL power amplifier design. Transistor Q23, time constant components, R101, C30 and SCR Q22 form the timer. Refer to schematic in Section 7.

The loss of phase circuitry was modified to improve performance and reduce the required number of components.

The connector housing plate was redesigned to provide clearance above the switching package. The connector plate contains 23 feedthru RF filters used for reducing conducted interference.

6.2 S-Band PA D-1

The NASA S-Band PA Engineering model D-1 was modified with new power supplies and a different RF circuit layout.

6.2. RF Path Modification

The original PA D-1 had the RF components distributed throughout the inside of the unit interconnected with relatively long coax cables. In D-1 (modified) all the RF components, including the TWT amplifiers, and interface connectors are in the top half of the assembly. The RF components are interconnected with relatively short coaxial cables thus providing lower RF loss. The only RF component changed in D-1 (modified) was the load isolator. The new isolator is slightly smaller and with one-third the weight of the Raytheon isolator used in the original unit. The isolator used is one that was purchased under NAS 9-7203 and transferred to NAS 9-8142. It should be mentioned that the diplexer is not packaged inside D-1 (modified) but is mounted on the bench test mounting fixture. Removal of the diplexer made the repackaging of the power supplies possible.

6.2.2 Power Supplies

New power supplies were required because of inefficient and sometimes faulty operation of the original D-1. The new power supply design was adapted from the MOL S-Band PA. Two power supply assemblies are used, one supply for V1 and the other for V2. The necessary interlocking circuitry is provided in both assemblies to prevent both supplies operating at the same time. The new power supply uses a pre-regulator operating at 20 to 32 volts dc input driving a filament inverter.

The pre-regulator is a high efficiency switching regulator up-converter and is adjusted to provide +36 Vdc output under all input voltages and output loads. The switching regulator runs at 43 kHz. Refer to Section 7 for the D-1 (modified) schematic diagram. The regulated voltage is then used to power the filament inverter, timer circuit and the power inverter. The filament inverter is an oscillator running at 10 kHz. One output winding provides the 5.2 Vrms filament voltage. The winding has five taps to adjust the filament voltage to within ±0.1 Vrms.

The timer circuit consists of time constant components R51, R52, C31 and C32 to provide the 90 second ±30 second filament warm-up time. After 90 seconds Q18 conducts driving Q20 into saturation which switches SCR Q27. When Q27 switches, K1 "ON" coil is energized causing K1 contacts B1 and B2 to close, connecting the base circuit of the power inverter to the emitters. The power inverter is driven by the filament inverter at a 10 kHz rate and switches the primary of T3 with 36V peak square wave. Transformer T3 has five windings that are used for high voltage power and two windings that provide bias for the series regulator and TWT Anode 1 voltage. The high voltage is derived from the five windings after voltage doubling and connecting the outputs in series. This arrangement provides low peak inverse voltage on the rectifier diodes and elimination of high voltage breakdown inside the transformer.

The series regulator in the power supply sets the cathode to helix voltage at the proper value, -1650 Vdc and keeps it constant for all helix loads. The series regulator is very similar to the one used in the Block II S-Band PA and the PP-2 (modified) PA.

The following is a list of relays used and their functions in the power amplifier.

Relay	Type	Function
K1	DC	High Voltage ON/OFF power supply 1
K2	DC	ON/OFF Power Supply 1
K3	DC	ON/OFF Power Supply 2
K4	RF	Input Bypass/Amplify
K5	DC	High Voltage ON/OFF Power Supply 2
K6	RF	Input RF Transfer
K8	RF	Output RF Transfer
K10	RF	Output Bypass/Amplify

6.2.3 Efficiency

The power supply efficiency measured about 80 percent using resistive loads in place of the TWT.

The overall efficiency is calculated below:

$$\text{Overall Efficiency} = \frac{\text{RF Output}}{\text{DC Input}} (100)$$

$$\frac{19.5}{108.5} (100) = 18 \text{ percent}$$

Using the overall efficiency and the measured power supply efficiency of 80 percent, the TWT efficiency is calculated:

$$0.8 \text{ (TWT eff.)} = 0.18$$

$$\text{TWT Efficiency} = \frac{0.18}{0.8} = 22.5 \text{ percent (includes 1.3 db RF output loss)}$$

It should be noted that the calculations do not reflect the approximate 1.3 db loss present from the TWT output jack to the TNC connector, J384 on the outside of the power amplifier. The 1.3 db loss corresponds to a 0.74 correction factor.

$$\text{TWT Efficiency} = \frac{22.5}{.74} = 30.3 \text{ percent}$$

The TWT specification requires a minimum efficiency of 30 percent to meet the 25 watt output power.

SECTION 7.0

SCHEMATICS OF POWER AMPLIFIER AFTER MODIFICATION

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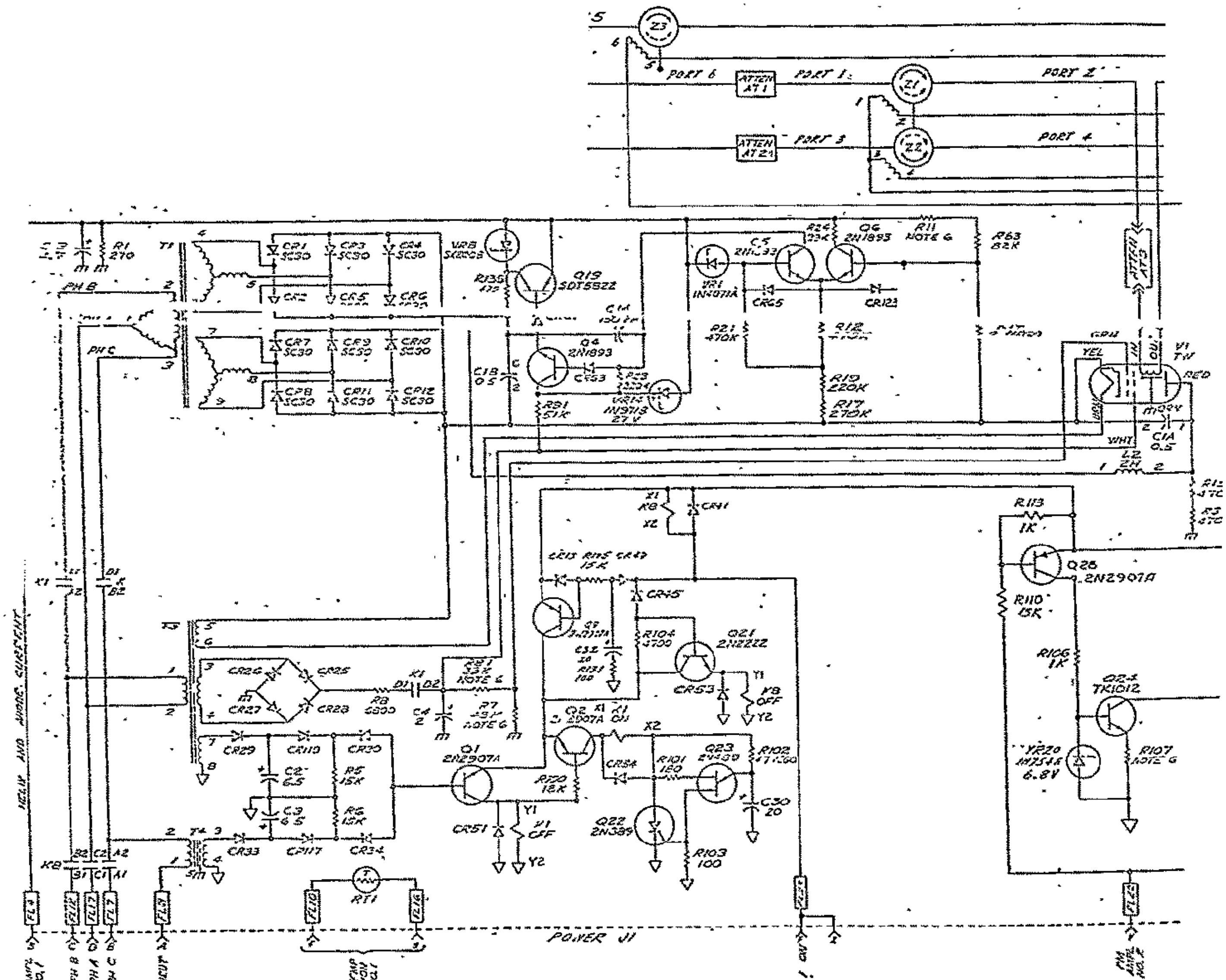

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FOLDOUT FRAME

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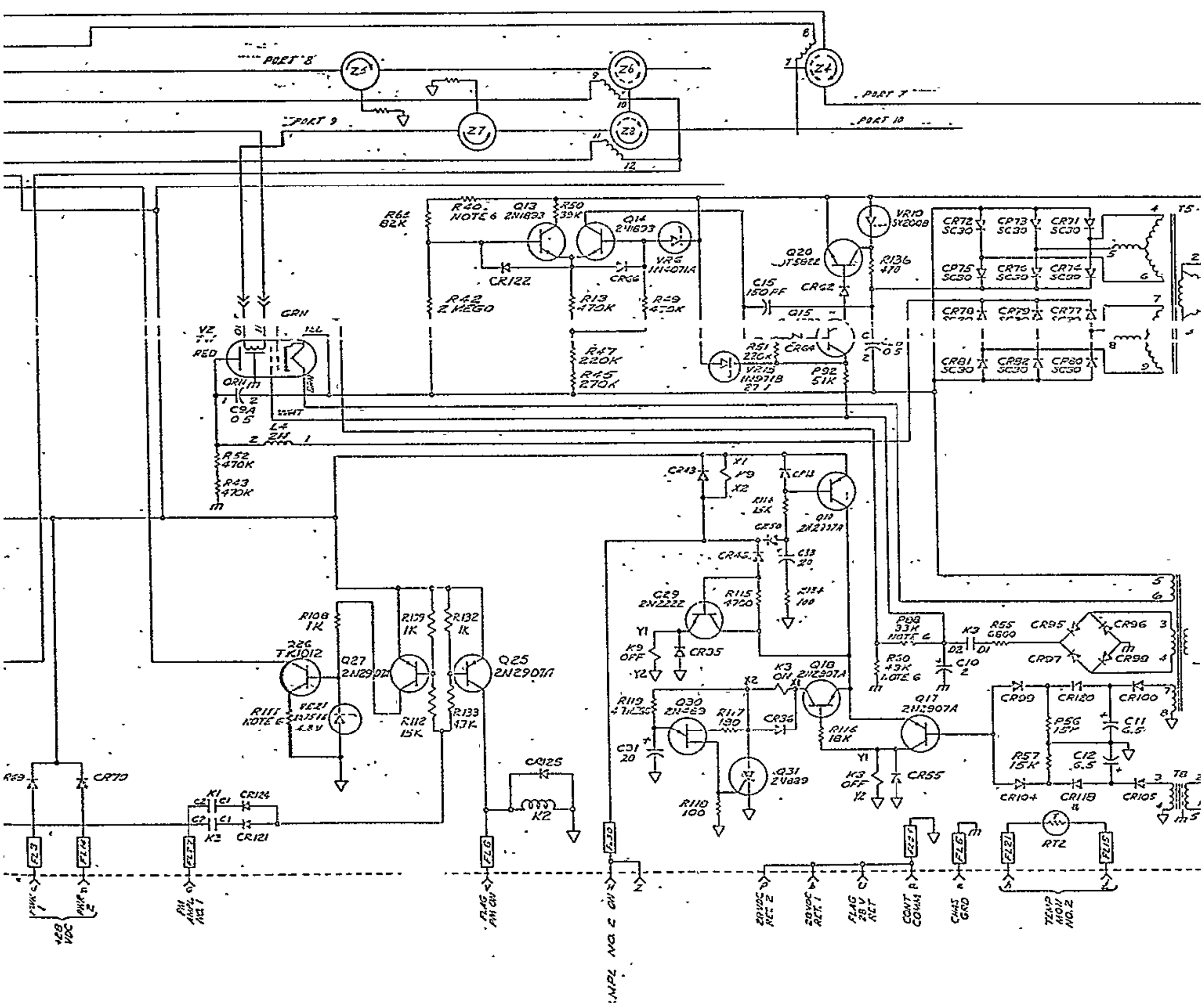

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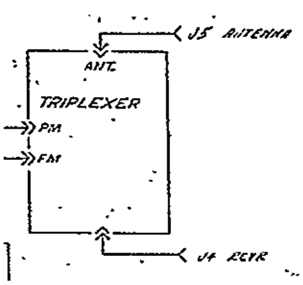

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTANCE VALUES ARE IN OHMS,
   CAPACITANCE VALUES ARE IN MICROFARADS,
   AND DIODES ARE TYPE 1N649.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED
3. Z1 THROUGH Z6 ARE SEMI-LATCHING CIRCULATORS.
4. PA SHOWN IN OFF STATE WITH 28 VOLTS APPLIED TO UNIT. (PM BYPASS)
5. Z1 AND Z2 LATCH IN BYPASS MODE WHEN PM OFF.
6. NOMINAL VALUE SHOWN. FINAL VALUE DETERMINED IN PRODUCTION TEST.
7. Z4 THROUGH Z6 ARE IN LATCHED STATE IN PRIMARY MO. (PM ON THROUGH AMPL NO 1. Z1 AND Z2 OUT OF BYPA; FM ON THROUGH AMPL NO. 2)
8. ↓ DENOTES COMMON CONNECTION.
9. Z7 AND Z8 ARE LOAD ISOLATORS.
10. BOTH AMPLIFIERS ARE SET FOR REDUCED POWER IN THE PRIMARY MODE.

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SIZE	GUIDE	JOB	FIG	REDUCTION	1/1	KEY

FOR COLLINS RADIO COMPANY INTERNAL PUBLICATION PURPOSES ONLY

QTY REQD	SYM	ITEM NO	COLLINS PART NO	PART OR IDENTIFYING NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	CODE [illegible]

LIST OF MATERIAL OR PARTS LIST

MATERIAL: NONE

APPLIED FINISH: NONE

HEAT TREATMENT: NONE

UNLESS OTHERWISE SPECIFIED

CONTRACT NO

NAME	DATE
DR R. STOW	[illegible]
CHK [illegible]	[illegible]
APPD [illegible]	[illegible]
L. Batson [illegible]	

COLLINS RADIO COMPANY
CEDAR RAPIDS IOWA

SCHEMATIC DIAGRAM — S-BAND POWER AMPLIFIER, [illegible] PP-2 MODIFIED.

SIZE: J
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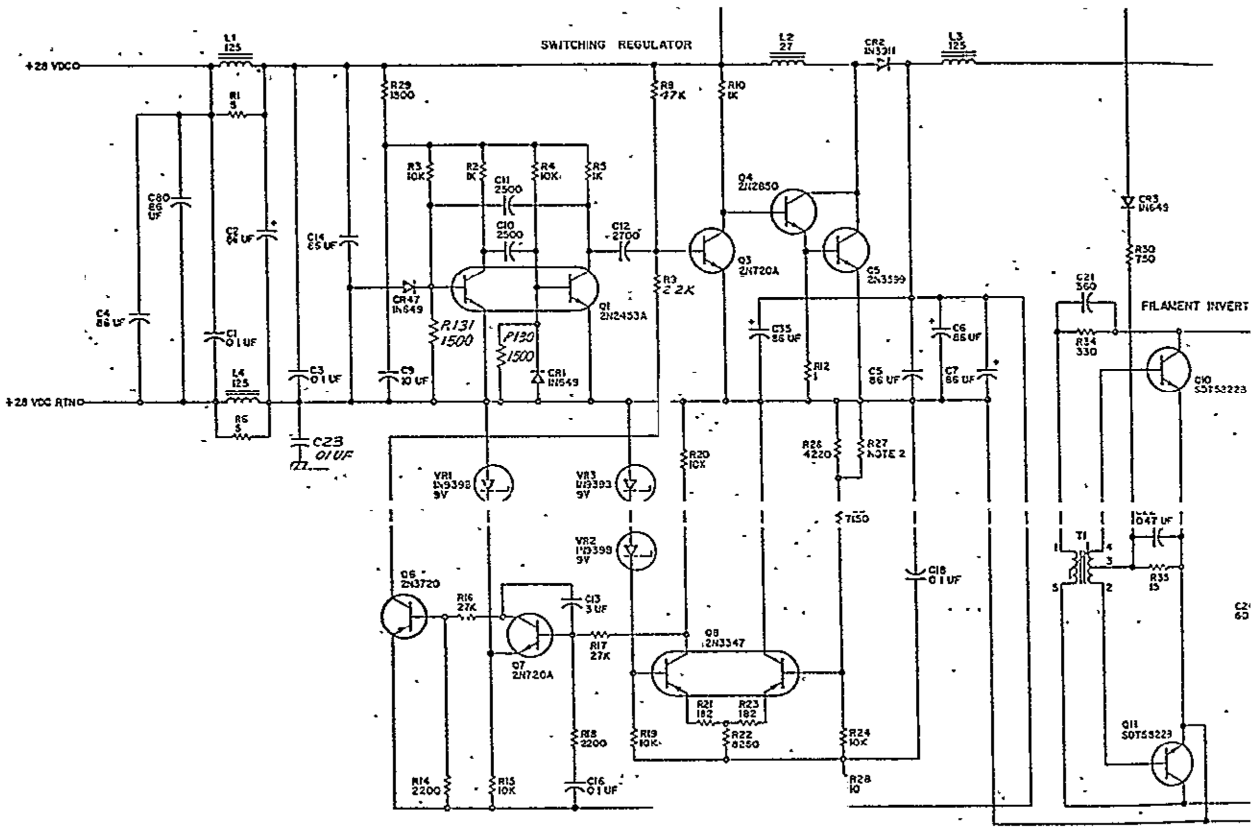

NOTES
1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN PICOFARADS AND ALL INDUCTANCE VALUES ARE IN MICROHENRYS
2. VALUES SELECTED IN FINAL TEST

POWER SUPPLY NO 1

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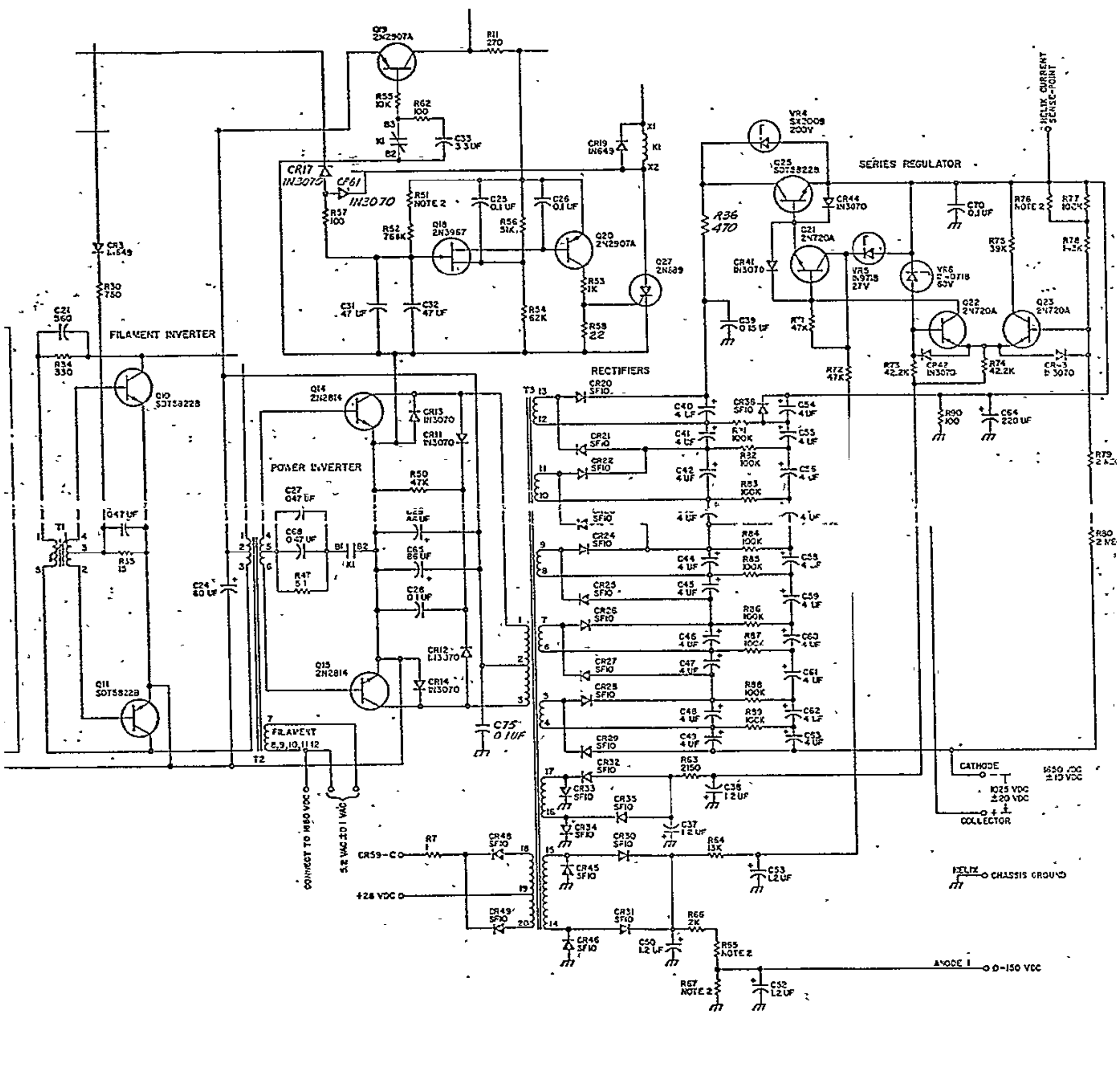

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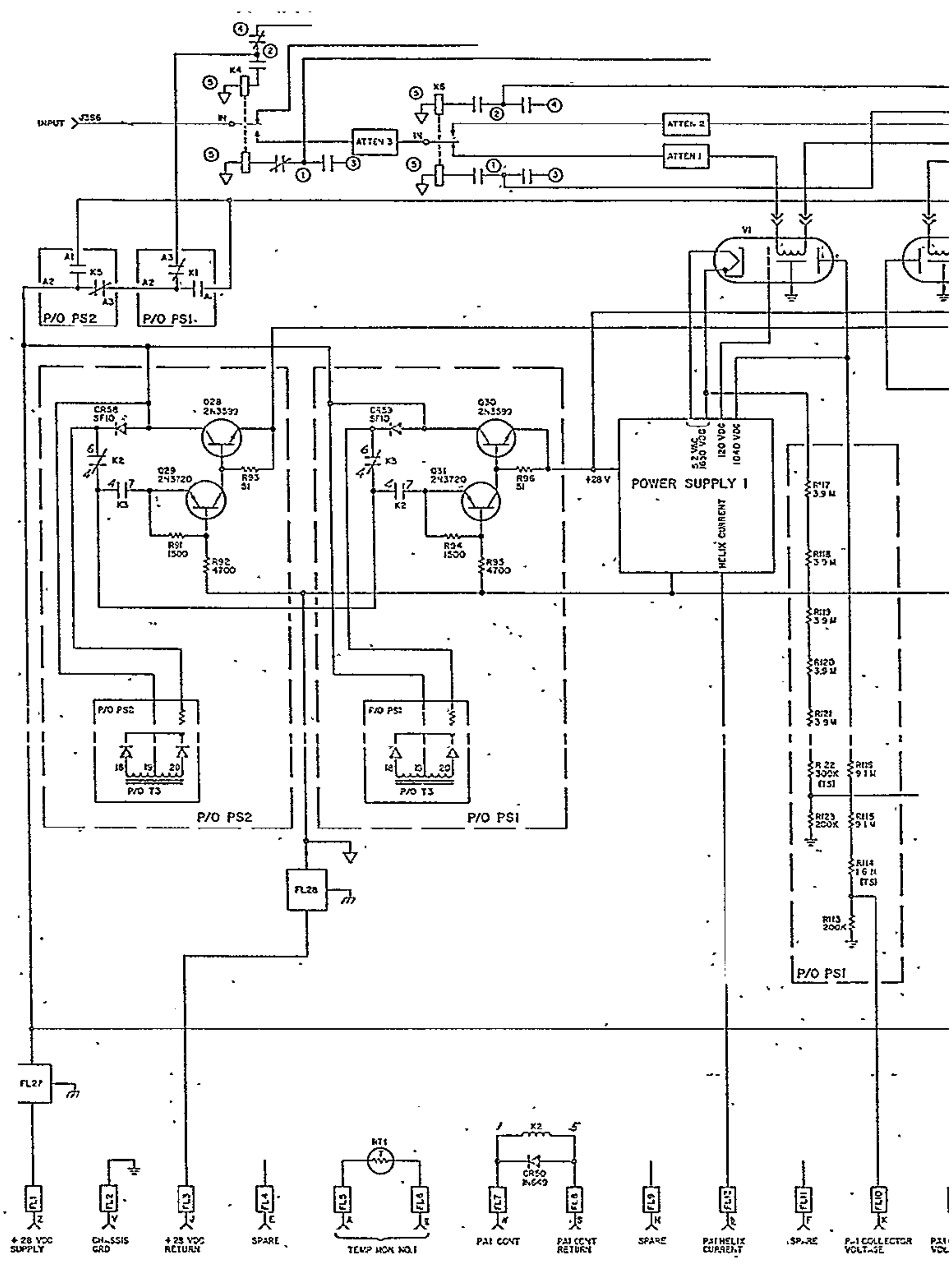

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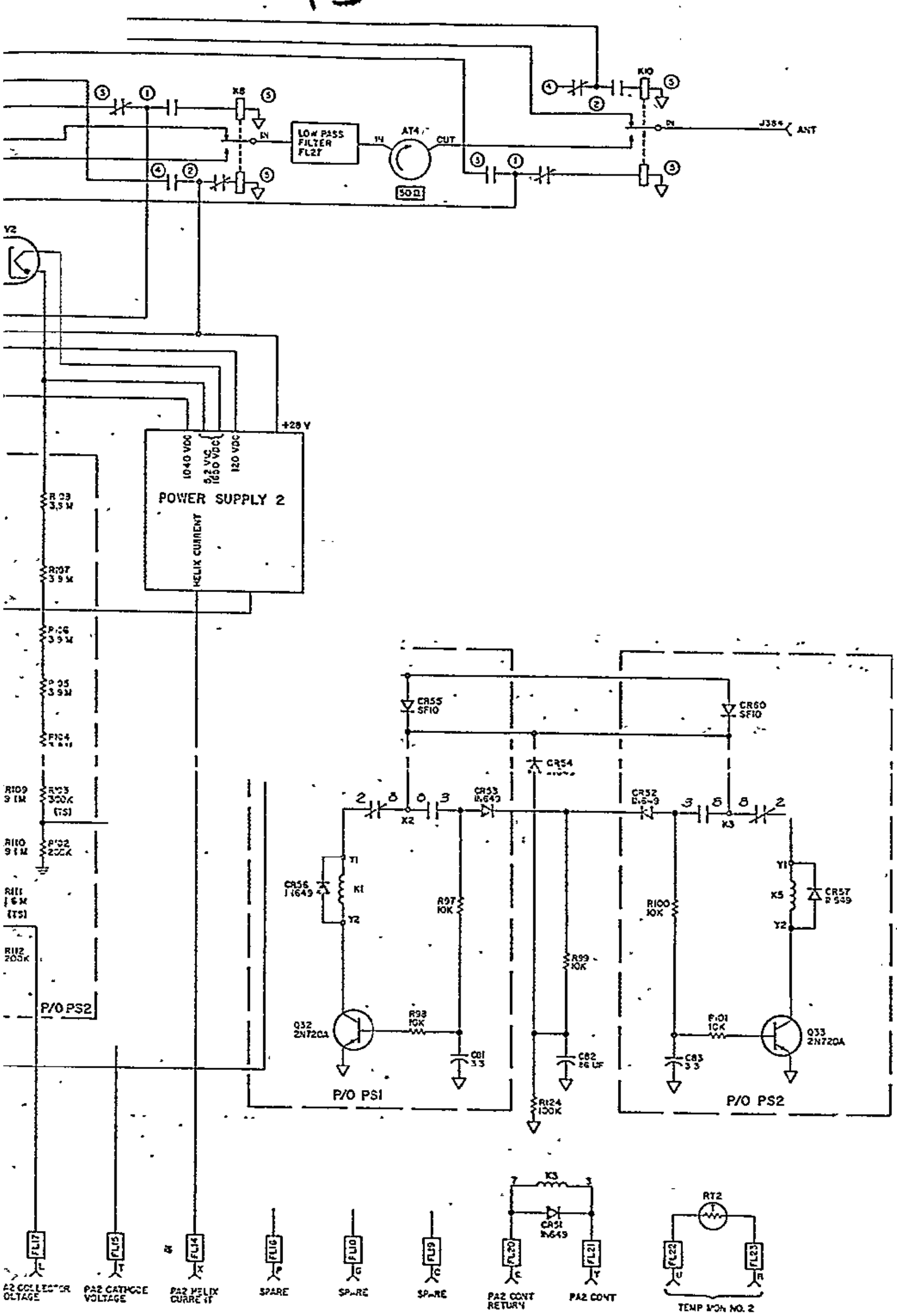

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MATERIAL SEE SHEET 1	DR AE KRAVSECK	SCHEMATIC DIAGRAM - NASA S-BAND PA, D-1 (MODIFIED)
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REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

REV STATUS OF SHEETS	REV															
	SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

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COLLINS RADIO COMPANY

DALLAS, TEX. NEWPORT BEACH, CALIF CEDAR RAPIDS, IA

ACCEPTANCE TEST PROCEDURE FOR
MODIFIED BLOCK II S-BAND POWER AMPLIFIER
NASA CONTRACT NO. NAS 9-8142

SIZE	CODE IDENT NO.	DWG NO.
A	13499	PP2 (MODIFIED)

SCALE SHEET 1 of 15

1.0 SCOPE

NA

2.0 REFERENCE INFORMATION

NA

3.0 REQUIREMENTS

3.1 Weight

Weigh the unit and record weight.

4.0 TEST REQUIREMENTS

4.1 Power Input and RF Power Output

Prior to starting the test connect the counter as shown by the dashed lines on Figure 1 to make sure the signal generators are on the correct frequency.

CAUTION: The drive levels should be set to the approximate drive level required before connecting to the input to avoid overdriving the traveling wave tubes.

Since the RF output measurement system shown in Figure 1 has no provision for separating the FM and PM carriers, it is necessary to turn off the rf drive on one carrier in order to measure the power output in the other carrier. When both carriers are on the output meter should read approximately 3 db higher than with either carrier individually. Both carriers should be on for power input measurements.

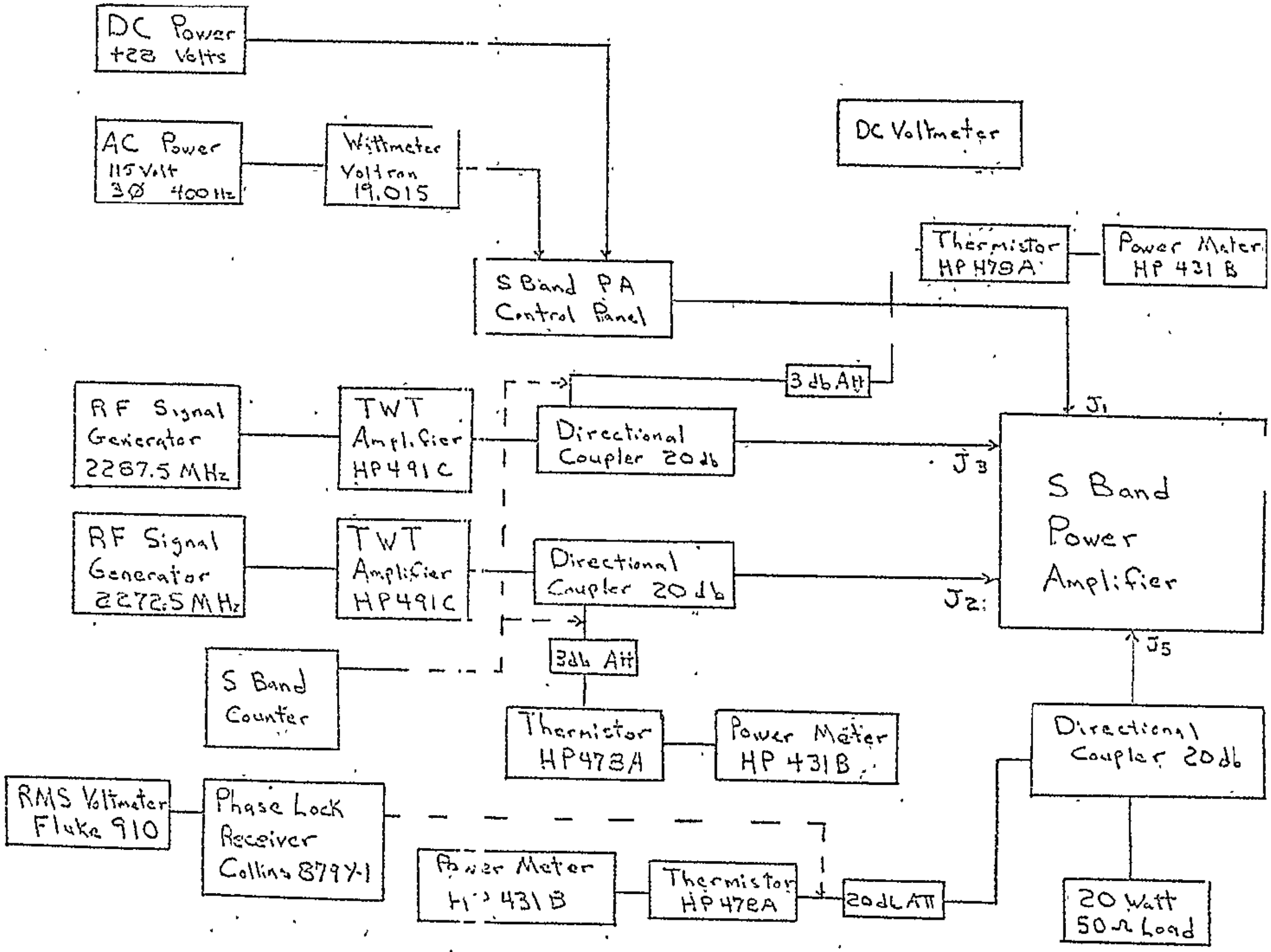

Fig 1 General Test Setup

23

SIZE A | CODE IDENT NO. | DWG NO.

SCALE | REV | SHEET 3

Measure RF Power Output and power input for each of the combinations of voltage and RF Drive levels shown on the data sheets. DC voltage is measured on the front panel of the control unit and the current is measured as a function of voltage drop across an 0.1 ohm resistor. Therefore the DC current is ten times the voltage reading in volts.

The RF Drive and RF Output measuring system must be calibrated and the appropriate calibration factors must be used in order to read power in dbm.

4.2 Phase Stability

For the Phase Stability Tests connect the Phase Lock Receiver as shown by the dashed line on Figure 1. Connect True RMS Voltmeter to the Dynamic Phase Error output on the receiver. Since no filtering is provided ahead of the receiver, the FM Carrier should be shut OFF when measuring the phase jitter.

Set the PM drive level to 24.7 dbm, the line voltage to 115 volts and the DC voltage to 28 volts with PM in Amp 1 and Amp 1 and 2 to OFF measure the phase jitter in bypass mode to establish a reference.

Turn on both Amp1 and 2 and measure jitter after completion of the 90 second warmup. Calculate jitter added by the power amplifier as shown on the data sheet.

Switch the PM to Amp 2 and repeat the phase jitter measurement and again calculate the added jitter as shown on the data sheet.

4.3 Warmup Time

Set PM to Amp 1 and both amplifiers to OFF. Then turn Amp 1 ON and note the time required from switch activation until the PM flag light comes on. Record time. Turn Amp 1 OFF.

Set PM to Amp 2 and turn Amp 2 ON and not time until the PM flag light turns on. Record.

4.4 Loss of Phase Protection

With Amp 1 in PM and Amp 1 ON, verify that switching OFF each phase of the three-phase power will cause the power amplifier to go to bypass and check the appropriate blanks on the data sheets.

With Amp 2 in PM and Amp 2 ON, verify that switching OFF each phase of the three-phase power will cause the power amplifier to go to bypass and check the appropriate blanks on the data sheets.

NOTE: If a phase switch is OFF for less than one second, the amplifier will turn back ON immediately. If it is OFF for more than one second it will be necessary to wait 90 seconds before proceeding.

4.5 Receive Insertion Loss

Measure the Receive insertion loss using the test setup shown in Figure 2. Connect the counter as shown in the figure by dashed lines and set the frequency to 2106.4 MHz before making measurement. Then with the input and output cables connected with a TNC Adapter set a convenient reference level. Remove the adapter and connect in the power amplifier. Receive insertion loss is the difference between the reference level and the level read on the mater after the power amplifier is connected. Record the loss.

4.6 Temperature Monitor Checks

A voltage is provided within the control panel which allows measurement of the thermistors in the Power Amplifier. The resistance of the thermistor is found by measuring the test point voltage on the control unit and calculating according to the equation shown below.

$$R = \frac{5.11 \times (V_{test\ point})}{20 - V_{test\ point}} = \_\_\_\_\text{K ohms}$$

Measure and record the resistance of both thermistors.

5.0 DATA

The data sheets in this section are marked with the applicable test paragraph number in parenthesis.

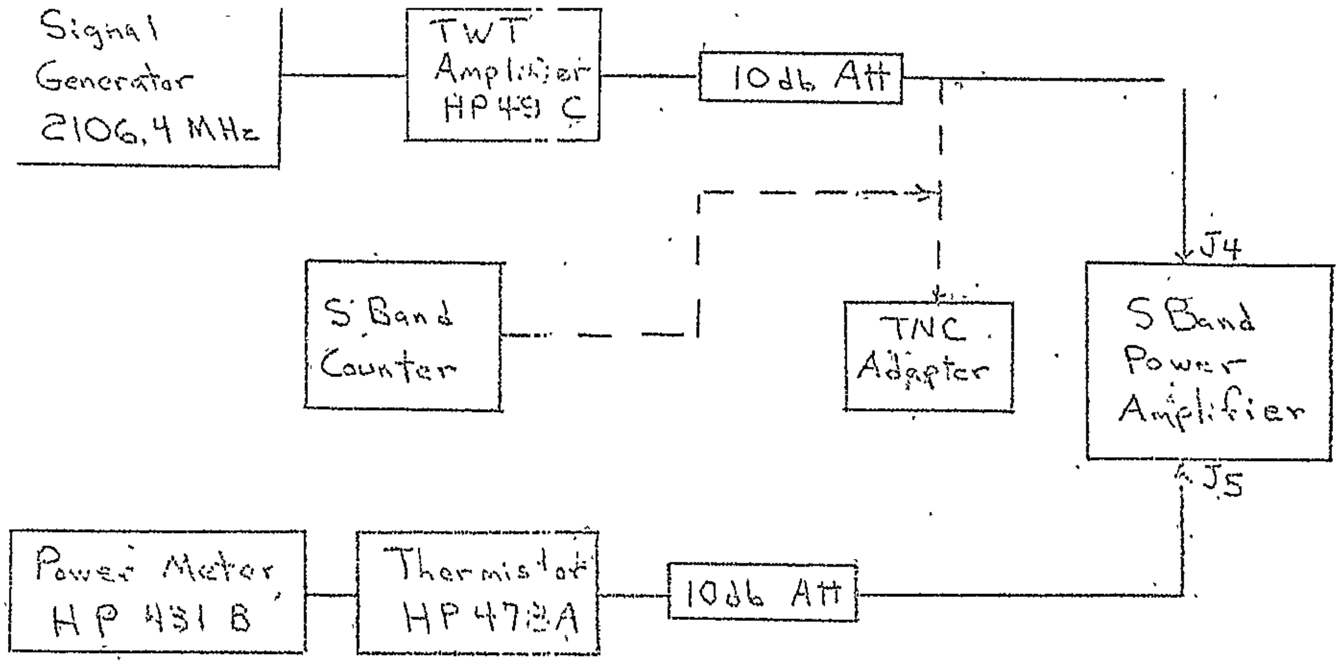

Fig 2 Receive Insertion Loss Test Setup

SIZE	CODE IDENT NO.	DWG NO.
A	13499	
SCALE	REV	SHEET

Date of Test 16 June 69

Tested By A Graff / L. York

(3.1) Weight.

Power Amplifier weight: 29# 11⅛ oz. NMT 32 lbs

(4.1) Power Output

Date of Test 16 June 69

PM Amp 1
AC Line Voltage 115

Tested By A Goff / L York

Mode Amp 1	Mode Amp 2	PM Drive (dbm)	FM Drive (dbm)	AC Power (watts)	DC Voltage (volts)	DC Current (Amp)	PM RF Output (dbm)	FM RF Output (dbm)	Limits	
OFF	OFF	24.7	OFF	X	28	0	22.2	X	PM Output DC Input	NLT 22.1 dbm NMT .286 Amps
Warmup	Warmup	OFF	OFF	6.1	28	.051	X	X	AC Input DC Input	NMT 30 watts NMT .286 Amps
ON	ON	24.7	OFF	X	28	X	41.0	X	PM Output	NLT 40.0 dbm
ON	ON	OFF	20.3	X	28	X	X	40.9	FM Output	NLT 40.0 dbm
ON	ON	24.7	20.3	168	28	.340	X	X	AC Input DC Input	NMT 180 watts NMT .286 Amps
ON	ON	23.6	OFF	X	28	X	40.95	X	PM Output	NLT 40.0 dbm
ON	ON	OFF	19.2	X	28	X	X	40.4	FM Output	NLT 40.0 dbm
ON	ON	23.6	19.2	168	28	.335	X	X	AC Input DC Input	NMT 180 watts NMT .286 Amps
ON	ON	25.6	OFF	X	28	X	40.9	X	PM Output	NLT 40.0 dbm
ON	ON	OFF	21.2	X	28	X	X	40.95	FM Output	NLT 40.0 dbm
ON	ON	25.6	21.2	170	28	.333	X	X	AC Input DC Input	NMT 180 watts NMT .286 Amps
ON	ON	24.7	OFF	X	22	.361	41.0	X	PM Output DC Input	NLT 40.0 dbm NMT .364 Amps
ON	ON	OFF	20.3	X	22	.296	X	40.9	FM Output DC Input	NLT 40.0 dbm NMT .364 Amps
ON	ON	24.7	OFF	X	32	.365	41.0	X	PM Output DC Input	NLT 40.0 dbm NMT .25 Amps
ON	ON	OFF	20.3	X	32	.368	X	40.9	FM Output DC Input	NLT 40.0 dbm NMT .25 Amps

SIZE A | CODE IDENT NO. 13499 | DWG NO. | SCALE | REV | SHEET 29

(4.1) Power Output

Date of Test 16 June 69

Tested By A Graff / L York

PM Amp 2
AC Line Voltage 115

Mode		PM Drive (dbm)	FM Drive (dbm)	AC Power (watts)	DC Voltage (volts)	DC Current (Amps)	PM RF Output (dbm)	FM RF Output (dbm)	Limits
Amp 1	Amp 2								
OFF	OFF	24.7	OFF		28	.269	22.2		PM Output NLT 22.1 dbm DC Input NMT .286 Amps
Warmup	Warmup	OFF	OFF	6.3	28	.319			AC Input NMT 30 watts DC Input NMT .286 Amps
ON	ON	24.7	OFF		28		40.8		PM Output NLT 40.0 dbm
ON	ON	OFF	20.3		28			40.85	FM Output NLT 40.0 dbm
ON	ON	24.7	20.3	172	28	.608			AC Input NMT 180 watts DC Input NMT .286 Amps
ON	ON	23.6	OFF		28		40.6		PM Output NLT 40.0 dbm
ON	ON	OFF	19.2		28			40.6	FM Output NLT 40.0 dbm
ON	ON	23.6	19.2	172	28	.605			AC Input NMT 180 watts DC Input NMT .286 Amps
ON	ON	25.6	OFF		28		40.65		PM Output NLT 40.0 dbm
ON	ON	OFF	21.2		28			40.8	FM Output NLT 40.0 dbm
ON	ON	25.6	21.2	175	28	.604			AC Input NMT 180 watts DC Input NMT .286 Amps
ON	ON	24.7	OFF		22	.546	40.8		PM Output NLT 40.0 dbm DC Input NMT .364 Amps
ON	ON	OFF	20.3		22	.547		40.8	FM Output NLT 40.0 dbm DC Input NMT .364 Amps
ON	ON	24.7	OFF		32	.639	40.8		PM Output NLT 40.0 dbm DC Input NMT .25 Amps
ON	ON	OFF	20.3		32	.642		40.8	FM Output NLT 40.0 dbm DC Input NMT .25 Amps

Date of Test 16 June 69

Tested By A Goff / L York

(4.2) Phase Stability

Reference Jitter

V_o = Max. voltage (Loop Open) .59 volts RMS

V_L = Output voltage (Loop Locked) .006 volts

$\phi_A = 0.707 \frac{V_L}{V_o}$ .0072 Radians RMS

Amp 1 Phase Jitter

V_o = Max. voltage (Loop Open) .59 volts RMS

V_L = Output voltage (Loop Locked) .009 volts RMS

$\phi_B = 0.707 \frac{V_L}{V_o}$ = .0108 Radians RMS

Amp 1 Jitter = $\sqrt{\phi_B^2 - \phi_A^2}$ = .008 Radians RMS NMT 0.05

Amp 2 Phase Jitter

V_o = Max. voltage (Loop Open) .59 volts RMS

V_L = Output voltage (Loop Locked) .009 volts RMS

$\phi_C = 0.707 \frac{V_L}{V_o}$ = .0108 Radians RMS

Amp 2 Jitter = $\sqrt{\phi_C^2 - \phi_A^2}$ = .008 Radians RMS NMT 0.05

Date of Test 16 June 69

Tested By A Graff / L York

(4.3) Warmup Time

Amp 1	94	Sec	NLT 60 NMT 120
Amp 2	91	Sec	NLT 60 NMT 120

Date of Test 16 June 69

Tested By A Graff / L York

(4.4) Loss of Phase Protection

Amp 1

Bypass with Phase A OFF	✓ OK
Bypass with Phase B OFF	✓ OK
Bypass with Phase C OFF	✓ OK

Amp 2

Bypass with Phase A OFF	✓ OK
Bypass with Phase B OFF	✓ OK
Bypass with Phase C OFF	✓ OK

Date of Test 16 June 69

Tested By A Groff / L York

(4.5) Receive Insertion Loss

2.05 db NMT 2.5 db

SIZE	CODE IDENT NO.	DWG NO.
A	13499	34
SCALE	REV	SHEET 14

-090-002-Rev. 6, 68

Date of Test 16 June 69
Tested By A Graff / L York

(4.6)

Temp Monitor Amp 1 .540 K ohms

Temp Monitor Amp 2 .540 K ohms

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

DASH NO. -001

REV	–	–																			
SHEET	21	22																			
REV. STATUS OF SHEETS — REV	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

THE SYMBOL – IN THE REV STATUS BLOCK DENOTES ORIGINAL ISSUE

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327

CONTRACT NO. NAS 9-5549

NAME	DATE
DR R. Y. Jackson	6-22-66
CHK K. F. Wright	6-22-66
APPD [illegible]	8-7-66

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

ACCEPTANCE TEST PROCEDURE
FOR
S-BAND POWER AMPLIFIER, P/N 514-1400

SIZE	CODE IDENT NO.	DWG NO.
A	13499	514-1435 36

SCALE | WT | SHEET 1 OF 22

-593-50

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

SIZE	CODE IDENT NO.	DWG NO.	
A	13409	514-1435	37
SCALE	WT		SHEET 2

1.0 SCOPE

1.1 This Acceptance Test Procedure applies to the S-Band Power Amplifier Equipment Part No. 512-1400-XXX, manufactured by Collins Radio Company, Cedar Rapids, Iowa. The S-Band Power Amplifier Equipment is an Electronic Replaceable Assembly for use in the S-Band Section of the Apollo Spacecraft Lunar Excursio Module (LEM).

1.2 All initial adjustments and calibration must have been performed on this equipment prior to acceptance testing.

2.0 REFERENCE INFORMATION

This acceptance test procedure is based on the following documents.

2.1 SPECIFICATIONS

NAS 9-5549, Article I, Exhibit A, Statement of Work, dated December 8, 1965, and applicable modifications thereto.

2.2 DRAWINGS

NASA-MSC Drawing LL0380-00110-31

3.0 TEST EQUIPMENT AND ENVIRONMENTAL REQUIREMENTS

3.1 TEST EQUIPMENT

The equipments listed in Table I or their equivalents are required to [illegible] the acceptance testing on the S-Band Power Amplifier.

NOTE: All test equipment shall operated in accordance with manufactures' specified primary power for a period of not less than one (1) hour prior to performance of any acceptance testing.

3.2 ENVIRONMENTAL REQUIREMENTS

Unless otherwise specified, all tests on the S-Band Power Amplifier shall be performed under the following conditions:

3.2.1 PRIMARY POWER SOURCE: +28 VDC

3.2.2 AMBIENT TEMPERATURE: 76° ± 10°F

3.2.3 AMBIENT HUMIDITY: 90% max.

3.2.4 AMBIENT ATMOSPHERIC PRESSURE: Normal Factory Ambient

3.2.5 OPERATIONAL DUTY CYCLE: Continuous

3.2.6 COOLING: Maintain the following conditions:

1. Coolant inlet temperature: 80°F

2. Coolant flow rate: 25 pounds/hour.

3.2.7 WARMUP PERIOD: 90 second automatic time delay

TABLE OF TESTS

PARAGRAPH	TEST NAME	PAG
4.0	Mechanical Inspection	10
4.2	Inspection Methods	10
4.2.1	General Assembly	10
4.2.2	Dimensions, Weight, and Center of Gravity Tests	10
5.0	Environmental	11
6.0	Electrical Tests	11
6.4	Preliminary Tests and Inspection	12
6.5	Detailed Functional Tests	13
6.5.1	By-Pass Mode	13
6.5.2	Full Power Mode	13
6.5.3	Phase Stability	14
6.5.4	Input VSWR	15
6.5.5	Diplexer Receive Insertion Loss	16

TABLE I TEST EQUIPMENT

ITEM	MANUFACTURER	MODEL OR TYPE NO.	DESCRIPTION	RANGE	ACCURACY
	Hewlett-Packard	HP-491C	Traveling Wave Tube Amplifier	Minimum 30 db Gain at 2 to 4 gc.	
	Collins	879Z-1	Crystal Controlled Signal Generator	2282.5 mc	
	Collins	879Y-1	Phase Lock Receiver		
	Fluke	910A	RMS Voltmeter	0.1 Millivolt to 3000 volts	± 1% of full scale
	Lambda	LA8-08BM	Power Supply	75 to 330 VDC 0 to 0.8 amps	
	Lambda	LE-110-M	Power Supply	0 to 9 VDC 0 to 20 Amps	
	Harrison Labs	809A	Power Supply	0 to 40 VDC @ 0 to 10 Amps	
	Dymec	2401A	Digital Voltmeter	0.001 to 1000 VDC	± 0.02%
	Collins		Interconnection Box		
	Narda	3022	Directional Coupler	20 db Attenuation	
	Hewlett-Packard	HP478-A	Thermistor Mount		

SIZE A | CODE IDENT NO. 13499 | DWG. NO. 514-1435

SCALE NONE | WT | SEE SHEET 1 | SHEET 6

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TABLE I TEST EQUIPMENT (Cont'd)

ITEM	MANUFACTURER	MODEL OR TYPE NO.	DESCRIPTION	RANGE	ACCURACY
	Hewlett-Packard	HP431B	Power Meter	0.01 to 10 mw	$\pm$ 3% or full scale
	Narda	771-20	Attenuator	20 db Attenuation	
	Bird	81B	RF Load	0 to 80 watts	
	Beckman	7580R	Transfer Oscillator	dc to 12,000 mc	
	Beckman	7360R	Universal EPUT and Timer (Counter)	dc to 2 mc	$\pm$ 0.001% or $\pm$ 1 count
	Alfred	2177	Slotted Line		
	Hewlett-Packard	HP415D	SWR Meter		
	Hewlett-Packard	HP 8614	Signal Generator	0.8 to 2.4 kmc	
	General Radio	GR874G-10	Attenuator	10 db Attenuation	

SIZE A | CODE IDENT NO. 13408 | DWG. NO. 514-1435

SCALE NONE | WT | SEE SHEET 1 | SHEET 7 | REV

4.0 MECHANICAL INSPECTION

The mechanical inspection of the completely assembled unit will be performed prior to environmental or electrical testing. Should any disassembly, repair of replacement be necessary during or after acceptance testing of the final unit configuration, the overall length, width and height of the unit must be measured in accordance with the applicable dimensions provided in this section. The dimensions listed in the inspection table may be measured or inspected in any practical order necessary.

4.1 DIMENSION AND FEATURE CLASSIFICATION

4.1.1 The mechanical inspection is categorized into three separate classifications which are defined as follows:

CLASS 1 - Major interface dimensions and features which will be checked 100%.

CLASS 2 - Detail part dimensions which will not be checked by virtue of their earlier 100% inspection at the detail part level.

CLASS 3 - Dimensions or features which require only a visual check to verify conformance of equipment specification control drawing.

4.1.2 Only Class 1 and 3 dimensions and features will be checked or measured during acceptance testing. Those dimensions and features not listed in this document are Class 2.

4.2 INSPECTION METHODS

4.2.1 General Assembly

Check visually for missing or loose screws and for damage of any kind, such as, nicks, dents, or scratches on outside surfaces of the Assembly.

4.2.2 Dimensions, Weight, and Center of Gravity Tests

Record Name, Manufacturer, etc., of measuring equipment on TEST EQUIPMENT LIST included in data sheets.

Remove the unit under test from the handling adapter.

Weigh the complete S-Band PA. Record this weight on the Data Sheet.

Measure the unit under test per the Installation Control Drawing, Collins part no. 514-1460, utilizing the following measuring methods as prescribed on the Data Sheets and record the required dimensions on the Data Sheets.

4.2.2 Continued

Measuring Method:

1. Measure mounting hole diameters with Go and No-Go plug gages. "Go" diameter .2122 in., "No-Go" diameter .2152 inch. (Plug #P-151838-5 of Gage CRC no. 117-0032-887-000.)

2. Measure mounting hole locations on the Ferranti Co-ordinate Measuring Machine. Mount the unit under test on the Ferranti table per Figure 1. Establish a datum line thru the centers of the two end holes on one mounting rail. Measure all hole locations from this datum line and from another datum line established perpendicular to the first datum line and thru the center of one of the first datum line holes. Perform method 13 at this time.

3. Measure the case length, excluding connectors and screwheads, and case width over flanges dimensions and the case body width dimension with a vernier caliper. Average 2 readings.

4. Turn the unit under test upside down on a surface plate and measure the two 4.000 inch maximum height of case dimensions with a dial indicator height gage and a PLA-CHEK gage.

5. Measure the co-planer parallelness of the mounting flanges (per drawing 514-1460) by mounting the unit under test on parallels. Place the parallels so the case bottom surface clears the surface plate. Place the unit under test on the bars so that each end of one mounting flange surface rests on the top surface of a bar, and the center of the other mounting flange surface rests on one end of the top surface of another bar. Measure the difference in height of the highest and lowest point on the mounting flange surface that is supported only in the center. Make this measurement with a dial indicator height gage and a PLA-CHEK gage.

6. Check visually for correct key and keyway orientation (per drawing 514-1460) connector.

   Check visually for legibility, and correct numbers for J384, J385, J385, and P383 marking. Check visually also that the connectors are located approximately as shown on 514-1460.

8. Measure case symmetry per drawing number 514-1460 as follows:

   Use angle plate, spacers, and three equal length bars as shown in Figure 2. Clamp in place so mounting plane is 90° to flat plate and basic datum line, thru first and last holes as established in method 2, is parallel to flat plate. Use dimension coded A as found per method 2 and using a dial indicator height gage and a PLA-CHEK gage determine the minimum B dimension and the maximum C dimension.

   $D = C - B$

   $\frac{A-D}{2}$ must = $B \pm .030$

4.2.2 Continued

9. Measure the center of gravity location in the "X", "Y", and "Z" axes with the balance table and a scale. Tie with light cord or thread output cable so that the connector is approximately in "mated position". For the "Z" axis measurement, rest the unit under test on a side on parallels placed equidistant from the center line of the balance table. Axes identified in 514-1460.

10. Measure the 7/8 inch dimension from end of flange to mounting hole by resting the end of the unit under test on 1.000 inch wide bars on a surface plate. Use a dial indicator height gage and a PLA-CHEK gage for this measurement.

11. Measure flat area of mounting flanges defined by 5 1/4 max dimension using flat-scale.

12. Measure the mated location of connector P383. Support the unit under test with parallels on a surface plate. Locate bars totaling 3/4 inch less than support parallels centered approximately 2 inches forward of the connector end of the unit. Connector should be capable of being located as defined on drawing.

13. Measure mounting flange symmetry per drawing number 514-1460 as follows:

Utilize set-up established in method 2. Measure and record B (maximum) and C(max) as defined in Figure 1. Use A as found in method 2. C-A must = B$\pm$.030

14. Measure flange thickness using a micrometer. Use average of 4 values

5.0 ENVIRONMENTAL

5.1 No environmental tests will be performed as a part of acceptance testing.

6.0 ELECTRICAL TESTS

THIS SECTION PROVIDES the preliminary tests and test equipment setup require for functionally testing the S-Band Power Amplifier assembly.

6.1 TEST EQUIPMENT TURN-ON

6.1.1 Ensure that the Primary Power Switch is OFF and that the MODE CONTROL switch is in BY-PASS position.

6.1.2 Activate power to the test equipment and allow one-hour warm-up period prior to performing any detailed tests.

6.2 TEST EQUIPMENT PRELIMINARY CONTROL SETTING

6.2.1 Complete the test equipment set-up in accordance with the following paragrap

6.2.2 Preliminary setup for TWT amplifier.

Preset the operating controls for the TWT amplifier as follows:

(1) Set TWT Amplifier in STANDBY mode.

(2) GAIN control fully counterclockwise.

6.2.3 Preliminary setup for Power Meter

Preset the operating controls for Power Meter as follows:

(1) MOUNT RES switch to 200

(2) RANGE switch to 10 mw.

6.2.4 Preliminary Setup for Signal Generator

Preset the operating controls for Signal Generator as follows:

(1) LEVEL SET control fully clockwise.

(2) FREQUENCY dial to midscale.

(3) OUTPUT ATTENUATOR to 0.

6.3 INTERCONNECTION OF S-BAND PA AND TEST EQUIPMENT

WARNING

ENSURE THAT THE 28 VDC POWER SWITCH IS IN OFF POSITION AND THE MODE SWITCH IS IN BY-PASS POSITION PRIOR TO CONNECTING THE S-BAND PA TO THE TEST EQUIPMENT.

6.3.1 All interconnections of the S-Band PA and test euqipment will be per Figure I, II, III, and IV as required by the test to be performed.

6.4 PRELIMINARY TESTS AND INSPECTION

6.4.1 Prior to connecting S-Band PA to test equipment, turn MONITOR SELECT TO Input V and adjust Primary Power Supply to +28.0 ± 0.1 VDC as indicated on the DVM.

6.4.2 Ensure that the MODE switch is in OFF position prior to connecting power connector to S-Band PA. Check to ensure correct mating of power connector.

6.5 DETAILED FUNCTIONAL TESTS

6.5.1 BY-PASS MODE

6.5.1.1 Connect test equipment per Figure I.

6.5.1.2 Adjust TWT amplifier for input power level of 376 mw and record input and output power meter readings.

6.5.2 FULL-POWER MODE

6.5.2.1 Switch MONITOR SELECT to Input V and adjust Primary Power Supply for 28.0 ± 0.1 VDC indication on DVM.

6.5.2.2 Place MODE CONTROL switch in PA1 position and record DC input current and voltage.

6.5.2.3 After 90 second automatic delay adjust TWT amplifier for input power level of 376 mw. If necessary, readjust Primary Power Supply for 28.0 ± 0.1 VDC.

6.5.2.4 Record DC input current and voltage.

6.5.2.5 Record input and output power meter readings.

6.5.2.6 Record DVM indications with MONITOR SELECT in PA1 Helix I, Coll V, and Cath V tively. Return MONITOR SELECT to Input V.

6.5.2.7 Adjust TWT amplifier for input power level of 354 mw.

6.5.2.8 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.9 Adjust TWT amplifier for input power level of 250 mw.

6.5.2.10 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.11 Adjust TWT amplifier for input power level of 500 mw and adjust Primary Power Supply for 24.8 ± 0.1 VDC.

6.5.2.12 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.13 Repeat 6.5.2.7

6.5.2.14 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.15 Repeat 6.5.2.9

6.5.2.16 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.17 Adjust TWT Amplifier for input power level of 500 mw and adjust Primary Power Supply for 31.5 ± 0.1 VDC.

6.5.2.18 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.19 Repeat 6.5.2.7

6.5.2.20 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.21 Repeat 6.5.2.9.

6.5.2.22 Repeat 6.5.2.4, 6.5.2.5, and 6.5.2.6.

6.5.2.23 Place MODE CONTROL switch in BY-PASS position.

6.5.2.24 Adjust Primary Power Supply for 28.0 ± 0.1 VDC.

6.5.2.25 Place MODE CONTROL switch in PA2 position and record DC input current and voltage.

6.5.2.26 Repeat steps 6.5.2.3 through 6.5.2.24 except that MONITOR SELECT is switched to positions for PA 2 as referenced in 6.5.2.6.

6.5.3 PHASE STABILITY

6.5.3.1 With MODE SELECT in BY-PASS position, Connect test equipment per Figure II.

6.5.3.2 Adjust TWT amplifier for input power level of 354 mw.

6.5.3.3 Set LOOP BANDWIDTH switch on Phase Lock Receiver to position 100 and MODE switch to NBFM position.

6.5.3.4 Set TEST METER selector switch to PM/NBFM IF LEVEL position.

6.5.3.5 Adjust RF LEVEL control and IF GAIN PM/NBFM control on receiver until TEST METER pointer indicates in green NB/PM LEVEL area.

6.5.3.6 Adjust PM/NBFM ACQ control dial on receiver for maximum voltage reading on RMS voltmeter. Record voltage (V_1).

6.5.3.7 Rotate MODE switch on receiver to PM position and TEST METER selector switch to PHASE LOCK TUNING position.

6.5.3.8 Adjust PM/NBFM ACQ CONTROL dial until TEST METER pointer aligns on orange PHASE LOCK TUNING area.

6.5.3.9 Record voltage reading (V_2) on RMS voltmeter.

6.5.3.10 Set MODE SELECT in PA1 position.

6.5.3.11 After the 90 second automatic delay, repeat steps 6.5.3.2 through 6.5.3.9 and record voltages V_3 and V_4 in lieu of V_1 and V_2 respectively.

6.5.3.12 Set MODE SELECT to BY-PASS position.

6.5.3.13 Set MODE SELECT to PA2 position.

6.5.3.14 After the 90 second automatic delay, repeat steps 6.5.3.2 through 6.5.3.9 and record voltages V_5 and V_6 in lieu of V_1 and V_2 respectively.

6.5.3.15 Calculate the phase jitter added by the PA as follows:

$$\phi\text{PA1 added} = 40.5\sqrt{\left(\frac{V_4}{V_3}\right)^2 - \left(\frac{V_2}{V_1}\right)^2} \text{ degrees rms.}$$

$$\phi\text{PA2 added} = 40.5\sqrt{\left(\frac{V_6}{V_5}\right)^2 - \left(\frac{V_2}{V_1}\right)^2} \text{ degrees rms.}$$

6.5.4 <u>INPUT VSWR</u>

6.5.4.1 Connect test equipment per Figure III.

6.5.4.2 Adjust signal generator, unmodulated, for frequency of 2282.5 + 0.2 mc as indicated by

6.5.4.3 With TWT amplifier gain set at minimum, switch MODE CONTROL to PA1.

6.5.4.4 After 90 second automatic time delay, slowly increase gain of TWT amplifier to obtain maximum indication on output power meter.

6.5.4.5 Apply square-wave modulation to signal generator.

6.5.4.6 Measure and record input VSWR.

6.5.4.7 Switch MODE CONTROL to BY-PASS and remove modulation.

6.5.4.8 With TWT amplifier gain set at minimum, switch MODE CONTROL to PA2.

6.5.4.9 Repeat steps 6.5.4.4 through 6.5.4.7 for PA2.

6.5.4.10 Adjust Signal Generator, unmodulated for frequency of 2290.0 ± 0.2 MC as indicated by counter.

6.5.4.11 Repeat steps 6.5.4.3 through 6.5.4.9.

6.5.4.12 Adjust Signal Generator, unmodulated for frequency of 2275.0 ±0.2 mc as indicated by counter.

6.5.4.13 Repeat steps 6.5.4.3 through 6.5.4.9.

REV

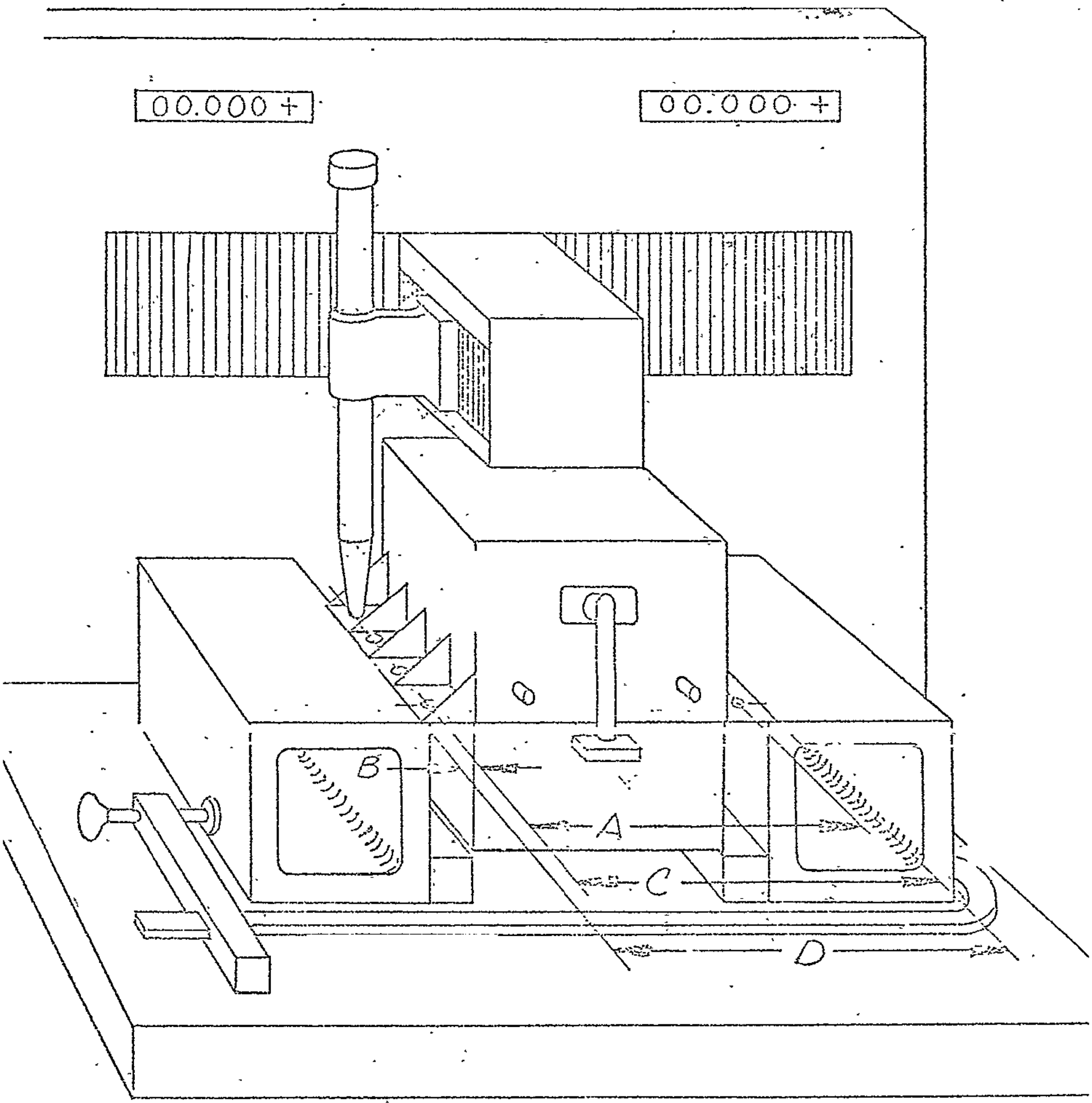

FIGURE 1

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1435

SCALE NONE | WT | SEE SHEET 1 | SHEET 17

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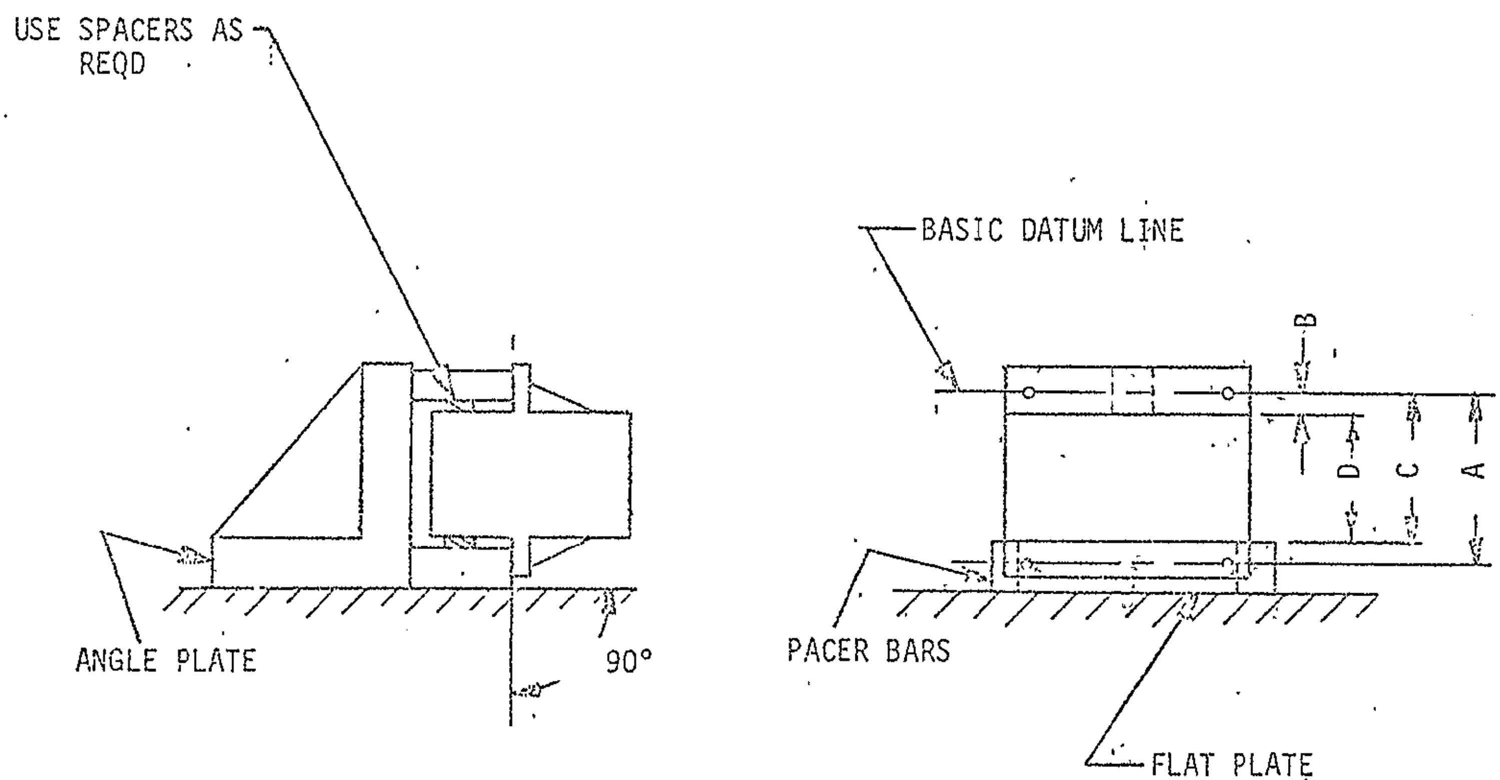

FIGURE 2

SIZE	CODE IDENT NO.	DWG. NO.
A	13409	514-1435
SCALE NONE	WT	SEE SHEET 1	SHEET 12

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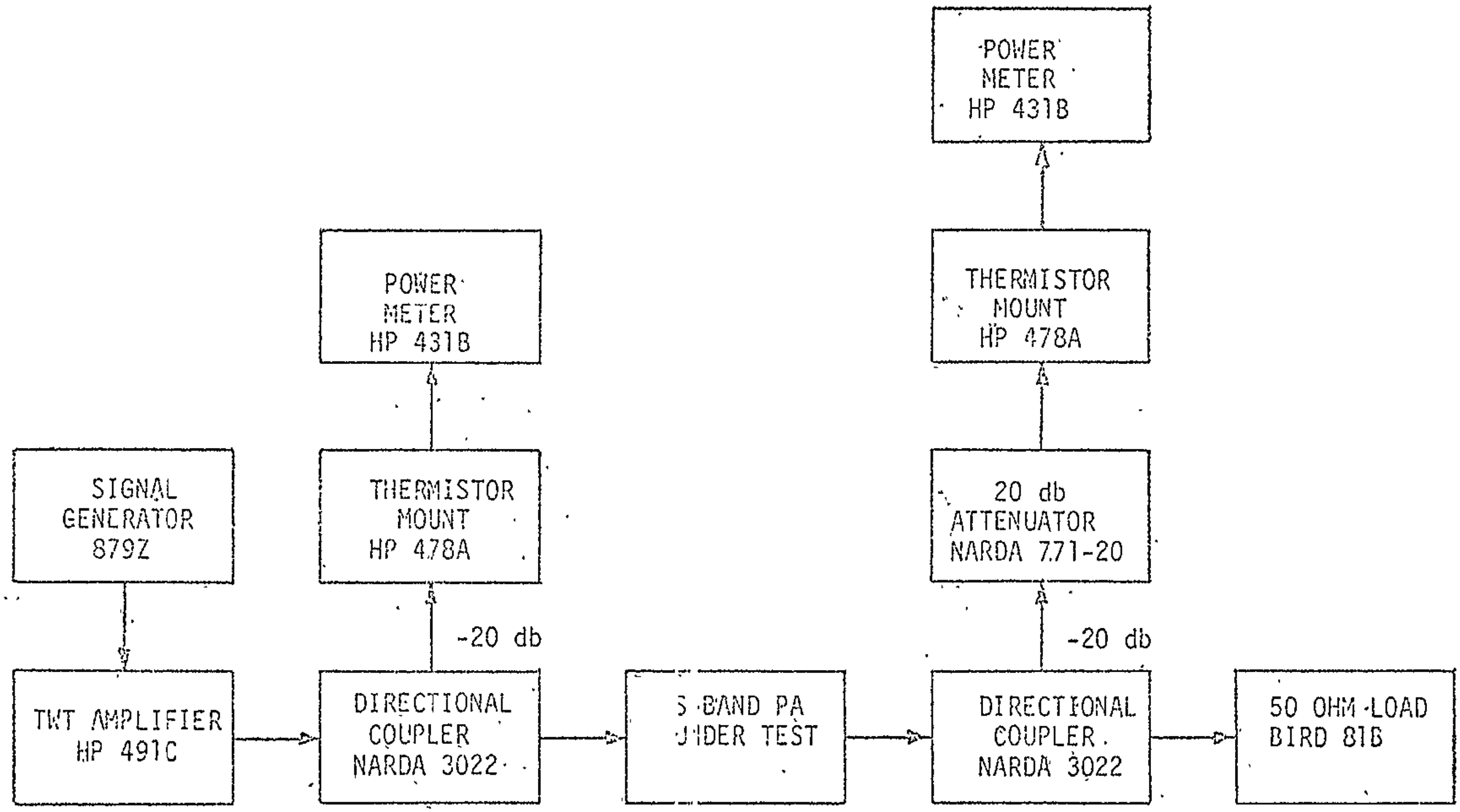
REV

FIGURE



BLOCK DIAGRAM
OF
RF POWER MEASUREMEN

SIZE A | CODE IDENT NO. 13400 | DWG. NO. 514-1435

SCALE NONE | WT | SEE SHEET 1 | SHEET 19

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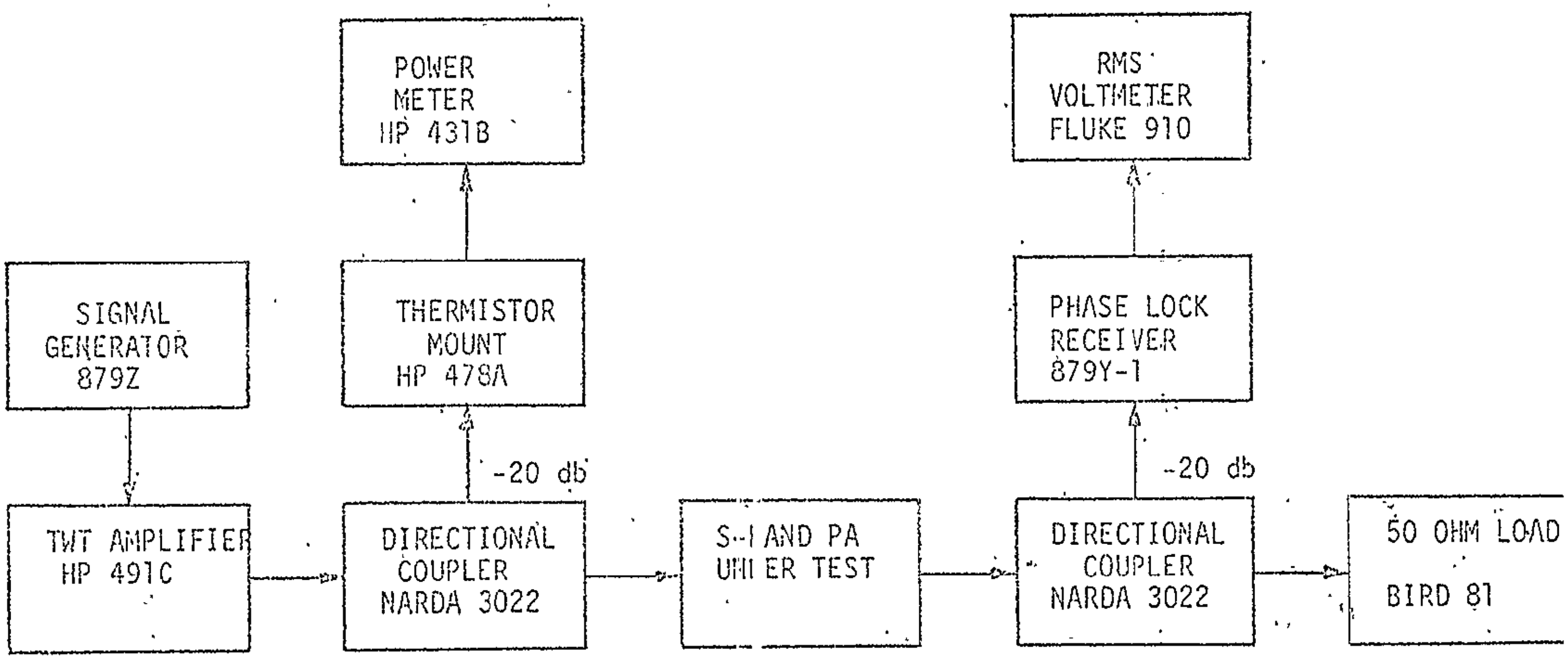
REV

FIGURE II



BLOCK DIAGRAM
OF
PHASE STABILITY MEASUREMENT

SIZE A | CODE IDENT NO. 13499 | DWG. NO. 514-1435
SCALE NONE | WT | SEE SHEET 1 | SHEET 2?

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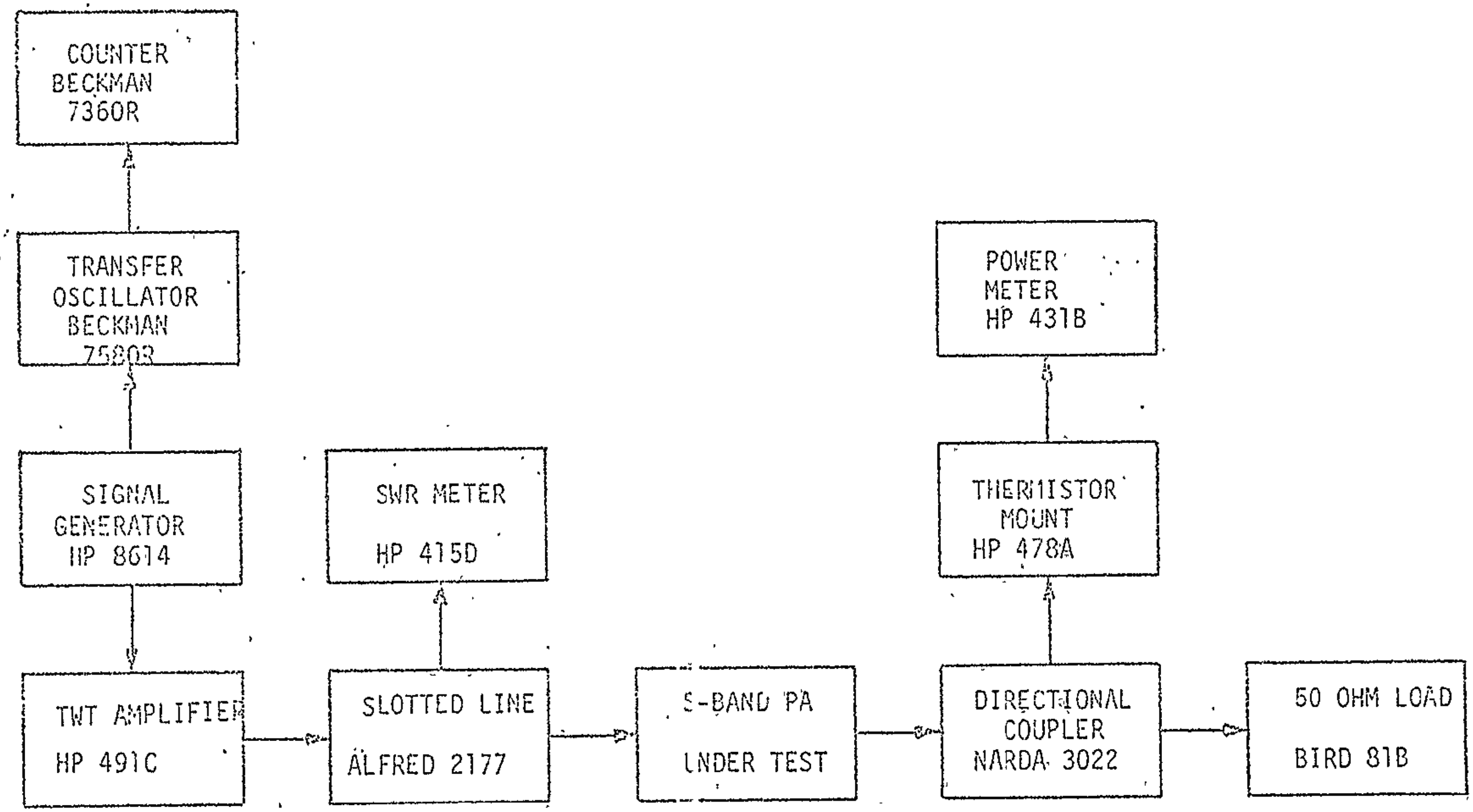
FIGURE III



BLOCK DIAGRAM
OF
INPUT VSWR MEASUREMENT

SIZE A	CODE IDENT NO. 13499	DWG. NO. 514-1435
SCALE NONE	WT	SEE SHEET 1
SHEET 21		

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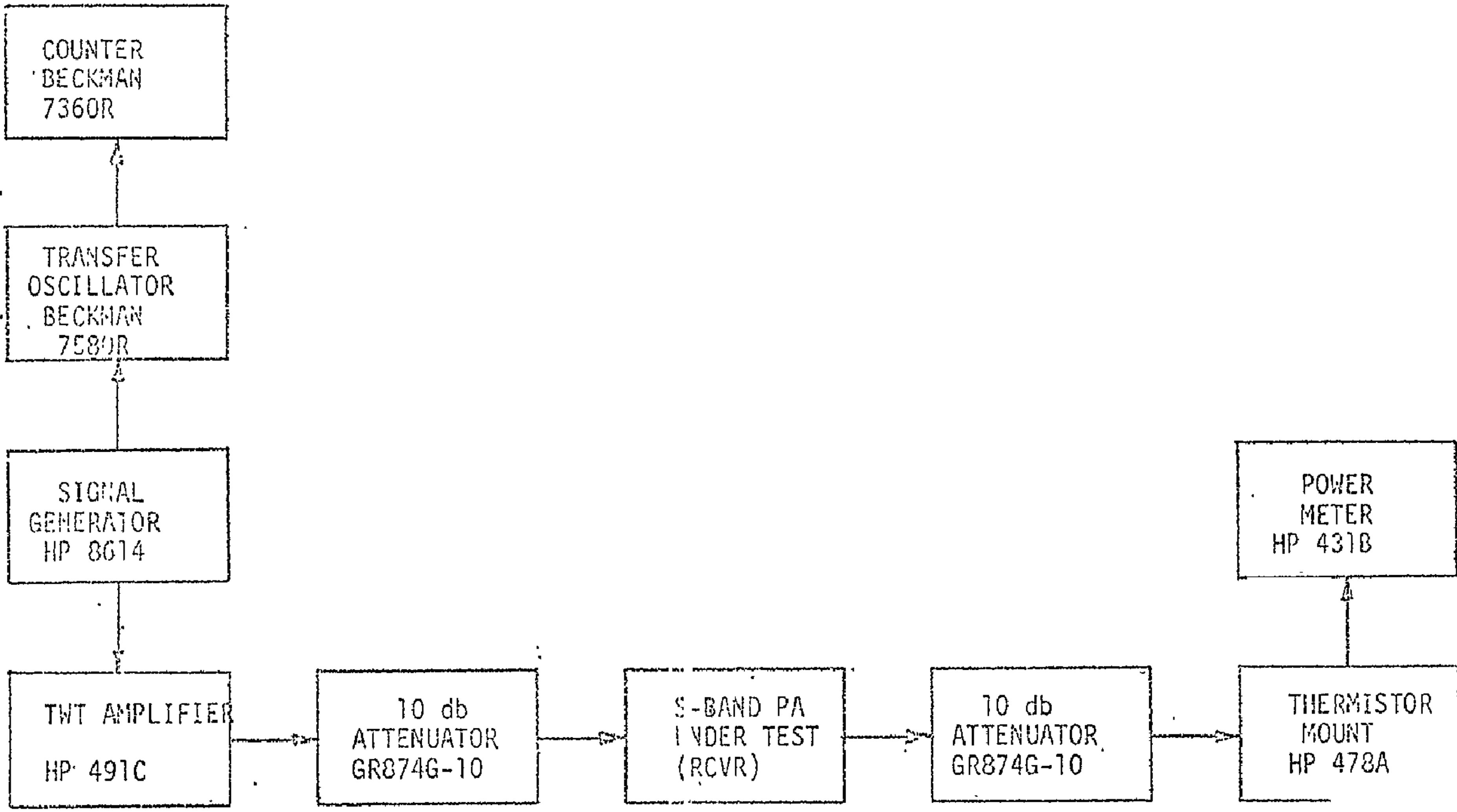
FIGURE IV



BLOCK DIAGRAM
OF
RECEIVER INSERTION LOSS MEASUREMENT

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1435

SCALE NONE | WT | SEE SHEET 1 | SHEET 22

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		MEASURED	LIMITS
6.5	DETAILED FUNCTIONAL TESTS		
6.5.1	BY-PASS MODE		
6.5.1.2	Input Power Meter reading	+5 dbm	
	Add test equipment loss	20.1 db	
	Input Power	25.1 dbm	+25 dbm
	Output Power Meter reading	-15.9 dbm	
	Add test equipment loss	40.1 db	
	Output Power	24.2 dbm	≥ 22 dbm
6.5.2	FULL POWER MODE		
6.5.2.2	DC Input Current (Warmup-PA1)	.28 Amps	
	DC Input Voltage (Warmup-PA1)	0.27 Volts	+28.0 + 0.1 VDC
	Input Power (Warmup-PA1)	2.55 Watts	≤15.0 watts
6.5.2.25	DC Input Current (Warmup-PA2)	.28 Amps	
	DC Input Voltage (Warmup-PA2)	.27 Volts	+28.0 ± 0.1
	Input Power (Warmup-PA2)	2.55 watts	≤15.0 watts

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.6

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.88 Amps	
	DC Input Voltage		28 Volts	See Note #1
	DC Input Power		108.5 Watts	120 Watts
6.5.2.5	Input Power Meter Reading		5.4 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		25.5 dbm	See Note #3
	Output Power Meter Reading		2.8 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.9 dbm	$\geq$ 41.0 dbm
6.5.2.6	Monitor Select Position (write appropriate position in space provided)	Helix I	0.720 VDC	
		Coll V	16.0 VDC	
		Cath V	5.64 VDC	
		Temp Monitor	.999 VDC	

NOTE #1. 28.0 $\pm$0.1, 24.8 $\pm$0.1, or 31.5 $\pm$0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT	SEE SHEET 1 / SHEET 13

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.8

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.90 Amps	
	DC Input Voltage		28 Volts	See Note #1
	DC Input Power		109.2 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		3.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		24.0 dbm	See Note #3
	Output Power Meter Reading		2.75 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.85 dbm	≥41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	0.705 VDC	
	(write appropriate position in space provided)	Coll V	16.0 VDC	
		Cath V	5.64 VDC	
		Temp Monitor	1.60 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.	
A	13499	514-1436	59
SCALE NONE	WT	SEE SHEET 1	SHEET 13

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.10

		MEASURED	LIMITS
6.5.2.4	DC Input Current	3.91 Amps	
	DC Input Voltage	28 Volts	See Note #1
	DC Input Power	109.3 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading	6.9 dbm	
	Add test equipment loss	20.1 db	
	RF Input Power	27.0 dbm	See Note #3
	Output Power Meter Reading	2.5 dbm	
	Add test equipment loss	40.1 db	
	RF Output Power	42.6 dbm	≥ 41.0 dbm

6.5.2.6	Monitor Select Position	Helix I	0.755 VDC
	(write appropriate position in space provided)	Coll V	66.0 VDC
		Cath. V	5.64 VDC
		Temp Monitor	6.01 VDC

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT	SEE SHEET 1	SHEET 13

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DATE 17 June 69

TESTED BY A Goff / L. York

6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.12

			MEASURED	LIMITS
6.5.2.4	DC Input Current		4.54 Amps	
	DC Input Voltage		24.8 Volts	See Note #1
	DC Input Power		112.5 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		5.4 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		25.5 dbm	See Note #3
	Output Power Meter Reading		2.75 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.85 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	0.64 VDC	
	(write appropriate position in space provided)	Coll V	16.0 VDC	
		Cath V	5.65 VDC	
		Temp Monitor	1.01 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT SEE SHEET 1	SHEET 13

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.14

		MEASURED	LIMITS
6.5.2.4	DC Input Current	4.53 Amps	
	DC Input Voltage	24.8 Volts	See Note #1
	DC Input Power	112.2 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading	3.9 dbm	
	Add test equipment loss	20.1 db	
	RF Input Power	24.0 dbm	See Note #3
	Output Power Meter Reading	2.7 dbm	
	Add test equipment loss	40.1 db	
	RF Output Power	42.8 dbm	≥ 41.0 dbm

			MEASURED
6.5.2.6	Monitor Select Position	Helix	0.641 VDC
	(write appropriate position in space provided)	Coll V	16.0 VDC
		Cath V	5.65 VDC
		Temp Monitor	1.01 VDC

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.16

			MEASURED	LIMITS
6.5.2.4	DC Input Current		4.58 Amps	
	DC Input Voltage		24.8 Volts	See Note
	DC Input Power		113.2 Watts	< 120 Watts
6.5.2.5	Input Power Meter Reading		6.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		27.0 dbm	See Note #3
	Output Power Meter Reading		2.55 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.65 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position.	Helix I	0.760 VDC	
	(write appropriate position in space provided)	Coll V	16.0 VDC	
		Cath V	5.66 VDC	
		Temp Monitor	4.01 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.18

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.46 Amps	
	DC Input Voltage		31.5 Volts	See Note #1
	DC Input Power		107 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		5.4 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		25.5 dbm	See Note #3
	Output Power Meter Reading		2.75 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.85 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	0.702 VDC	
	(write appropriate position in space provided)	Coll V	16.0 VDC	
		Cath V	5.65 VDC	
		Temp Monitor	1.02 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.20

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.38 Amps	
	DC Input Voltage		31.5 Volts	See Note #1
	DC Input Power		106.2 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		3.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		24.0 dbm	See Note #3
	Output Power Meter Reading		2.6 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.7 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	0.647 VDC	
	(write appropriate position in space provided)	Coll V	16.0 VDC	
		Cath V	5.66 VDC	
		Temp Monitor	1.02 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.22

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.38 Amps	
	DC Input Voltage		31.5 Volts	See Note #1
	DC Input Power		106.5 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		6.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		27.0 dbm	See Note #3
	Output Power Meter Reading		2.55 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.65 dbm	
6.5.2.6	Monitor Select Position	Helix I	0.764 VDC	
	(write appropriate position in space provided)	Coll V	16.0 VDC	
		Cath V	5.66 VDC	
		Temp Monitor	1.01 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.6 – 6.5.2.26

		MEASURED	LIMITS
6.5.2.4	DC Input Current	3.94 Amps	
	DC Input Voltage	28 Volts	See Note #1
	DC Input Power	110 Watts	≤ 120 Watts
6.5.2.5.	Input Power Meter Reading	5.4 dbm	
	Add test equipment loss	20.1 db	
	RF Input Power	25.5 dbm	See Note #3
	Output Power Meter Reading	2.75 dbm	
	Add test equipment loss	40.1 db	
	RF Output Power	42.85 dbm	≥ 41.0 dbm

6.5.2.6	Monitor Select Position	Helix I	0.978 VDC
	(write appropriate position in space provided)	Coll V	16.3 VDC
		Cath V	5.78 VDC
		Temp Monitor	1.02 VDC

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13490	514-1436
SCALE NONE	WT	SEE SHEET 1 / SHEET 13

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.8 – 6.5.2.28

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.97 Amps	
	DC Input Voltage		28.0 Volts	See Note #1
	DC Input Power		111 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		3.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		24.0 dbm	See Note #3
	Output Power Meter Reading		2.55 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.65 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	1.00 VDC	
	(write appropriate position in space provided)	Coll V	16.3 VDC	
		Cath V	5.78 VDC	
		Temp Monitor	1.03 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT SEE SHEET 1	SHEET 13

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.10 - 6.5.2.26

		MEASURED	LIMITS
6.5.2.4	DC Input Current	3.98 Amps	
	DC Input Voltage	28 Volts	See Note #1
	DC Input Power	111.3 Watts	$\leq$ 120 Watts
6.5.2.5	Input Power Meter Reading	1.9 dbm	
	Add test equipment loss	20.1 db	
	RF Input Power	22.0 dbm	See Note #3
	Output Power Meter Reading	2.5 dbm	
	Add test equipment loss	40.1 db	
	RF Output Power	42.6 dbm	$\geq$ 41.0 dbm

6.5.2.6	Monitor Select Position	Helix I	1.01 VDC
	(Write appropriate position in space provided)	Coll V	1.63 VDC
		Cath V	5.78 VDC
		Temp Monitor	1.03 VDC

NOTE #1. 28.0 $\pm$0.1, 24.8 $\pm$0.1, or 31.5 $\pm$0.1 VDC as applicable

NOTE #3. 27.0 dbm for 500 mw drive. 25.5 for 354 mw drive, and 24 for 250 mw

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT	SEE SHEET 1 — SHEET 13

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.12 - 6.5.2.26

			MEASURED	LIMITS
6.5.2.4	DC Input Current		4.63 Amps	
	DC Input Voltage		24.8 Volts	See Note #1
	DC Input Power		114.9 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		5.4 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		25.5 dbm	See Note #3
	Output Power Meter Reading		2.7 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.8 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	.448 VDC	
	(write appropriate position in space provided)	Coll V	16.3 VDC	
		Cath V	5.79 VDC	
		Temp Monitor	1.03 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT SEE SHEET 1	SHEET

DATE 17 June 69

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.14 – 6.5.2.26.

			MEASURED	LIMITS
6.5.2.4	DC Input Current		4.68 Amps	
	DC Input Voltage		24.8 Volts	See Note #1
	DC Input Power		116.1 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		3.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		24.0 dbm	See Note #3
	Output Power Meter Reading		2.5 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.6 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	1.01 VDC	
	(write appropriate position in space provided)	Coll V	16.3 VDC	
		Cath V	5.79 VDC	
		Temp Monitor	1.03 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.4 – 6.5.2.6.

			MEASURED	LIMITS
6.5.2.4	DC Input Current		4.68 Amps	
	DC Input Voltage		24.8 Volts	See Note #1
	DC Input Power		116.1 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		6.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		27 dbm	See Note #3
	Output Power Meter Reading		2.5 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.6 dbm	≥41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	1.02 VDC	
	(write appropriate position in space provided)	Coll V	16.3 VDC	
		Cath V	5.79 VDC	
		Temp Monitor	1.03 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.18 - 6.5.2.26

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.41 Amps	
	DC Input Voltage		31.5 Volts	See Note #1
	DC Input Power		102.5 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		5.4 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		25.5 dbm	See Note #3
	Output Power Meter Reading		2.7 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.8 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position (write appropriate position in space provided)	Helix I	0.953 VDC	
		Coll V	16.3 VDC	
		Cath V	5.79 VDC	
		Temp Monitor	1.05 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.20 - 6.5.2.26

		MEASURED	LIMITS
6.5.2.4	DC Input Current	3.43 Amps	
	DC Input Voltage	31.5 Volts	See Note #1
	DC Input Power	108 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading	3.9 dbm	
	Add test equipment loss	20.1 db	
	RF Input Power	24.0 dbm	See Note #3
	Output Power Meter Reading	2.5 dbm	
	Add test equipment loss	40.1 db	
	RF Output Power	42.6 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position Helix I	1.13 VDC	
	(write appropriate position in space provided) Coll V	1.63 VDC	
	Cath V	5.79 VDC	
	Temp Monitor	1.45 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
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6.5.2 FULL POWER MODE (CONT'D)

TEST TO PARAGRAPH NO. 6.5.2.22 - 6.5.2.26

			MEASURED	LIMITS
6.5.2.4	DC Input Current		3.43 Amps	
	DC Input Voltage		31.5 Volts	See Note #1
	DC Input Power		108 Watts	≤ 120 Watts
6.5.2.5	Input Power Meter Reading		6.9 dbm	
	Add test equipment loss		20.1 db	
	RF Input Power		27.0 dbm	See Note #3
	Output Power Meter Reading		2.5 dbm	
	Add test equipment loss		40.1 db	
	RF Output Power		42.6 dbm	≥ 41.0 dbm
6.5.2.6	Monitor Select Position	Helix I	1.03 VDC	
	(write appropriate position in space provided)	Coll V	16.3 VDC	
		Cath V	5.80 VDC	
		Temp Monitor	1.05 VDC	

NOTE #1. 28.0 ±0.1, 24.8 ±0.1, or 31.5 ±0.1 VDC as applicable.

NOTE #3. 27.0 dbm for 500 mw drive, 25.5 for 354 mw drive, and 24 for 250 mw drive.

SIZE	CODE IDENT NO.	DWG. NO.
A	13499	514-1436
SCALE NONE	WT	SEE SHEET 1 / SHEET 13

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S/N 01

DATE ~~[illegible]~~ 17 June 69

TESTED BY [illegible signature] / [illegible] York

6.5.3 PHASE STABILITY

6.5.3.6 V_1 : 0.690 volts

6.5.3.9 V_2 : 0.0085 volts

6.5.3.11 V_3 : 0.690 volts

V_4 : 0.0095 volts

6.5.3.14 V_5 : 0.690 volts

V_6 : 0.010 volts

6.5.3.15 Calculate phase jitter for each PA and record below:

PA1 added: .25 degrees rms $\leq 1°$ rms

PA2 added: .31 degrees rms $\leq 1°$ rms

6.5.4 INPUT VSWR	MEASURED	LIMITS
6.5.4.6 PA1 Input VSWR @ F_t	1.25 : 1	1.5:1
6.5.4.9 PA2 input VSWR @ F_t	1.29 : 1	1.5:1
6.5.4.11 PA1 input VSWR @ f_t+7.5 mc	1.28 : 1	1.5:1
PA2 input VSWR @ f_t+7.5 mc	1.26 : 1	1.5:1
6.5.4.13 PA1 input VSWR @ f_t-7.5 mc	1.17 : 1	1.5:1
PA2 input VSWR @ f_t-7.5 mc	1.21 : 1	1.5:1

Power Output at Mid Drive ~ 28V DC thru diplexer at 2282.5

Amp1 - 42.1 dbm

Amp2 - 42.1 dbm

Diplexer Insertion loss @ 2282.5 0.55 db

9.0 Conclusions and Recommendations

The equipment, delivered on this contract has exhibited the following deficiencies.

A. Apollo PP-2 (modified)

1. DC steady state power.
   (Specification limit 8 watts max., unit measured 19.1 watts at 28 V).

2. Use of a coaxial switch to correct the poor bypass isolation.

B. NASA S-Band PA, D-1 (modified)

1. No deficiencies noted.

9.1 Apollo PP-2 (Modified) Power Amplifier

The increase in dc power was due to the ferrite switching package. The additional power was required to meet the RF electrical characteristics. The switching package could be redesigned and the magnetic paths relocated to provide a more efficient unit. It was felt that the RF characteristics were primary and the dc power secondary. The object was to see what could be done in the space provided keeping the schedule and cost in mind.

[illegible] input impedance variations with frequency by adding or relocating a load isolator in the PM input line to the triplexer. This change along with the coil power reduction should be studied and cost estimates made. It should be noted that the Apollo Block II PA is very crowded and considerable layout effort will be required for any changes.

9.2 NASA S-Band PA D-1 (Modified)

The D-1 (modfied) unit performed as predicted at laboratory ambient conditions. The power amplifier should be tested under environmental conditions to further verify the overall reliability and performance under temperature extremes.

9.3 Ferrite Life Testing

The ferrite life testing, performed under this contract, provided for a demonstration of reliability, at room ambient conditions, for a total of 48,000 component operating hours. This does not suffice as a qualification of the device for space application in that there is no consideration of environmental extremes. A logical continuation of the effort, performed to date, would be the life testing of representative devices under environmental extremes, i.e., temperature and vibration.

APPENDIX A

LIFE TEST REPORT

ON

FERRITE CIRCULATORS

78

APPENDIX A

LIFE TEST REPORT

FERRITE CIRCULATORS

1.0 General

The purpose of this test was to gather data for use in evaluating the reliability of switchable ferrite circulators. Sufficient data of this nature is not presently available to establish a reliability figure in which confidence can be held.

2.0 Test Plan

2.1 Test Setup

All necessary test equipment including power supplies were mounted in one 6 foot high 19 inch rack. The circulator-switches were mounted behind a 8 inch high front panel for ease of removing units for loss measurements in the standards lab.

2.1.1 Test Signal Generation

Two sources of S-Band rf energy are available in the test rack. One source is the Collins built MOL MGE TTCV Test Transmitter. The other source employs the HP 491C TWT power amplifier excited by an appropriate signal generator. Either source drives a TWT amplifier whose output provides the 20 watt test signal.

The TWT amplifier was built for this test using spare TWT's from previous PA development projects. The amplifier power supply is basically the same circuit used in the Block II S-Band Power Amplifier except for the addition of circuitry for control and monitoring and protection against transients on the power lines.

2.1.2 Test Panel

The test panel assembly contains the circulators to be tested along with their control circuitry. Each circulator has its ports brought out to the panel TNC connectors. This arrangement provides convenience in performing periodic parameter measurements and also in selecting the desired test configuration.

2.1.3 Test Control Panel

The test control panel contains the circuitry for automatically switching the circulators (at a rate of 10 times per hour) and the test configuration terminations for monitoring the power being dissipated in the termination. The test control panel also counts the number of switching operations performed and totals the accumulated test hours.

In addition, the test control panel will interface with the TWT amplifier such that an amplifier failure will turn off the hour meter and switching control circuitry.

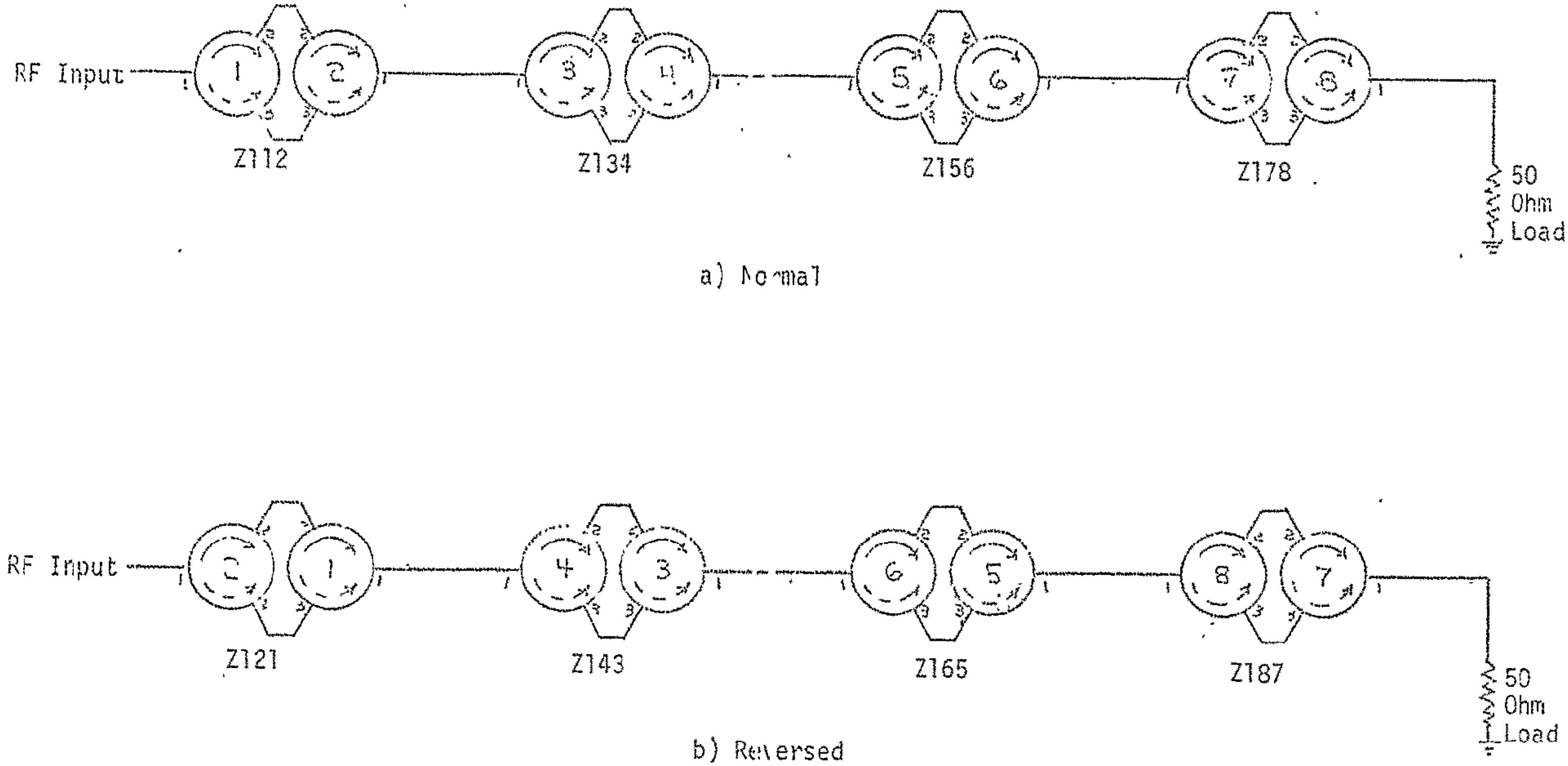

FIGURE 1. TYPICAL TEST CONFIGURATION

2.1.4 Power Meter

A HP power meter is also included in the test rack for monitoring the power out of the test configuration. Certain failures, in the test signal generating equipment and in the switches themselves, can be detected by observing a change in the level of power being dissipated in the termination. A directional coupler in the test control panel connects the power meter to the test configuration output through a connector available at the test control panel.

2.2 Test Procedure

The general test procedure was to apply 20 watts of rf energy to the input port of the test configuration. Periodically at every 250 hours the circulator test configuration is modified according to a pre-established plan such that the power level exposure of each circulator port is the same at the end of the test.

Every 1,000 hours, parameter measurements were taken on each circulator. A total of 48,000 hours of operation were logged on 8 circulators at the rate of 6,000 hours each.

2.2.1 Switch Configuration

A typical test configuration is shown in Figure 1. All 8 circulators are connected in a chain which is terminated in a 50 ohm load. This chain is made up of four groups of two units each, with the four groups being connected in series. Each of the groups of two units is connected in a specific manner as indicated by a four symbol designator:

ZABC

The letter Z is merely a group designator. Letters A, B, and C identify number positions which define the interconnection of ports within the group.

A = Defines the input and output ports
B = Defines which circulator switch provides the input port
C = Defines which circulator switch provides the output port

The unnamed ports of the group are connected together such that power flows from input to output.

2.2.2 Switch Configuration Variations

To insure that all circulator junctions are uniformly tested, the switch configuration will be changed periodically. By systemically altering the configuration every 250 hours, all 8 junctions will receive identical exposure, in terms of a time-power product (Time X Watts), in 6,000 hours of test operation.

2.2.3 Parameter Measurements

At 1,000 hour intervals parameter measurements of insertion loss and isolation were taken by the standards lab on each of the eight switchable circulators. To perform the measurements, the test panel was removed from the test rack and taken to the standards lab for the measurements. It was necessary to provide a 28 VDC power supply and a measurements control box to the standards lab for performing the measurements.

3.0 Test Results

Testing commenced on 19 July 1968 after initial measurements of VSWR, insertion loss and isolation were made. Testing was continued until 6014 hours were accumulated on 28 May 1969. Final data measurement was made in the standards lab.

Both the standard lab data sheets and graphs are included in this report to document the life test. The graphs show no pattern of degradation of performance. They do show measurement variations. The mean insertion loss was 0.65 db including internal panel coax cable and the isolation was greater than 20 db for each switch.

4.0 Conclusion

The eight circulator switches were subjected to 6,000 hours of operation giving 48,000 component hours of life test with no failures or degraded performance.

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S. 106-24 Ext. 2814/3903

COLLINS RADIO CO., CEDAR RAPIDS, IA.

Date 7-18-68	W P./File No. 2.2.9
E & M Laboratories, Circulator - Switch	
P/N 044-2731-130	FOR: Duane Hemphill.
EXT. 3815, E.P. 39-7486	

VSWR[1]

[2]CIRCULATOR#	FREQ. GHz	PORT #1 1-2	PORT #1 1-3	PORT #2 2-3	PORT #2 2-1	PORT #3 3-1	PORT #3 3-2
1	2.2	1.08/1	1.09/1	1.15/1	1.15/1	1.18/1	1.18/1
1	2.3	1.16/1	1.16/1	1.23/1	1.23/1	1.24/1	1.24/1
2	2.2	1.22/1	1.22/1	1.14/1	1.14/1	1.07/1	1.07/1
2	2.3	1.32/1	1.32/1	1.06/1	1.06/1	1.11/1	1.11/1
3	2.2	1.27/1	1.27/1	1.29/1	1.29/1	1.10/1	1.10/1
3	2.3	1.10/1	1.10/1	1.14/1	1.14/1	1.21/1	1.21/1
4	2.2	1.26/1	1.26/1	1.16/1	1.15/1	1.09/1	1.09/1
4	2.3	1.19/1	1.19/1	1.10/1	1.09/1	1.27/1	1.27/1
5	2.2	1.25/1	1.25/1	1.29/1	1.29/1	1.02/1	1.02/1
5	2.3	1.27/1	1.27/1	1.22/1	1.22/1	1.19/1	1.20/1
6	2.2	1.11/1	1.11/1	1.12/1	1.12/1	1.17/1	1.16/1
6	2.3	1.17/1	1.16/1	1.18/1	1.18/1	1.06/1	1.06/1
7	2.2	1.17/1	1.17/1	1.15/1	1.16/1	1.06/1	1.06/1
7	2.3	1.18/1	1.18/1	1.22/1	1.22/1	1.20/1	1.20/1
8	2.2	1.30/1	1.30/1	1.29/1	1.29/1	1.39/1	1.40/1
8	2.3	1.36/1	1.35/1	1.25/1	1.25/1	1.14/1	1.14/1

NOTES: 1. All measurements were made at the front panel and include the cables between the F.P. and circulator ports.

2. Circulator number as designated on the front panel.

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M S. 106-24 Ext. 2814/3903

COLLINS RADIO CO., CEDAR RAPIDS, IA.

Date 7-18-68	W.P./File No 2.2.9
E & M laboratories, Circulator - Switches.	
P/N 044-2731-130 FOR: Duane Hemphill,	
EXT. 3315, E.P. 39-7486	

II. THRU LOSS AND ISOLATION[1]

[2]CIRCULATOR #	FREQ. GHz	THRU LOSS BETWEEN PORT: 1 and 2	THRU LOSS BETWEEN PORT: 1 and 3	ISOLATION BETWEEN PORT: 1 and 2[3]	ISOLATION BETWEEN PORT: 1 and 3[4]
	2.2	0.6(6) dB	0.6(1) dB	19.4 dB	19.0 dB
	2.3	0.6 (9)	0.5(6)	19.0	19.6
2	2.2	0.6(3)	0.5(9)	30.7	23.0
2	2.3	0.8(0)	0.7(1)	25.0	29.5
3	2.2	0.6(9)	0.6(0)	32.6	17.9
3	2.3	0.6(2)	0.5(9)	20.2	22.6
4	2.2	0.5(9)	0.5(6)	29.0	24.6
4	2.3	0.6(1)	0.6(4)	18.8	27.8
5	2.2	0.6(4)	0.5(9)	[illegible]	[illegible]
5	2.3	0.6(4)	0.6(6)	20.9	19.5
6	2.2	0.6(9)	0.5(7)	23.3	23.2
6	2.3	0.5(5)	0.5(4)	31.4	20.0
7	2.2	0.5(7)	0.5(5)	29.9	21.7
7	2.3	0.6(2)	0.6(2)	20.3	20.0
8	2.2	0.5(3)	0.5(8)	16.2	18.5
8	2.3	0.6(5)	0.6(5)	21.7	18.2

NOTES:
1. All measurements were made at the front panel and include the cables between the F.P. and circulator ports.
2. Circulator number as designated on the front panel.
3. Thru path between ports 1 and 3.
4. Thru path between ports 1 and 2.

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S. 106-24 Ext. 2814/3903

COLLINS RADIO CO., CEDAR RAPIDS, IA.

Date 9-3-63 W.P./File No 2.2.9

Addn. to report dated 7-18-63

E&M Laboratories, Circulator - Switches

For: Duane Hemphill, EXT. 3815, EP 39-74

I. Thru Loss and Isolation

CIRCULATOR	FREQ. GHz	THRU LOSS BETWEEN PORT: 1 AND 2	THRU LOSS BETWEEN PORT: 1 AND 3	ISOLATION BETWEEN PORT: 1 AND 2	ISOLATION BETWEEN PORT: 1 AND 3
1	2.2	0.63 dB	0.59 dB	23.1 dB	22.3 dB
1	2.3	0.68	0.64	25.8	25.5
2	2.2	0.73	0.63	29.9	23.6
2	2.3	0.81	0.74	25.3	28.3
3	2.2	0.71	0.59	>35	18.2
3	2.3	0.63	0.61	20.7	24.0
4	2.2	0.64	0.60	29.8	24.8
4	2.3	0.63	0.68	19.2	29.4
5	2.2	0.71	0.64	>35	19.4
5	2.3	0.68	0.68	20.2	28.3
6	2.2	0.50	0.55	23.1	25.1
6	2.3	0.54	0.52	>35	21.[illegible]
7	2.2	0.59	0.57	29.6	22.2
7	2.3	0.65	0.64	20.6	20.2
8	2.2	0.62	0.70	16.7	19.6
8	2.3	0.67	0.62	22.0	19.4

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S 106-24 Ext. 2814/3903

COLLINS RADIO CO. CEDAR RAPIDS, IA.

Date 10-22-68	W.P./File No.
Addn. to reports dated 7-18-68 and 9-3-6	
E & M Laboratories, Circulators - Switc	
FOR: Duane Hemphill, Ext. 3815. EP 39-74	

I. Thru Loss and Isolation

CIRCULATOR	FREQ. GHz	THRU LOSS BETWEEN PORT: 1 AND 2	THRU LOSS BETWEEN PORT: 1 AND 3	ISOLATION BETWEEN PORT: 1 AND 2	ISOLATION BETWEEN PORT: 1 AND 3
1	2.2	0.63 dB	0.59 dB	22.5 dB	22.3 dB
1	2.3	0.63	0.59	21.0	21.1
2	2.2	0.68	0.59	29.2	24.7
2	2.3	0.72	0.66	26.5	30.7
3	2.2	0.73	0.62	>30	18.5
3	2.3	0.55	0.58	21.0	23.0
4	2.2	0.61	0.61	29.7	26.0
4	2.3	0.56	0.61	19.6	>30
5	2.2	0.67	0.62	>30	19.3
5	2.3	0.59	0.65	22.8	21.3
6	2.2	0.51	0.52	23.9	26.0
6	2.3	0.52	0.49	>30	22.6
7	2.2	0.61	0.57	28.6	22.1
7	2.3	0.62	0.64	21.6	20.3
8	2.2	0.58	0.60	17.2	19.6
8	2.3	0.58	0.54	21.5	19.1

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S 106-24 Ext. 2814/3903

COLLINS RADIO CO. CEDAR RAPIDS IA

Date 12-4-68 W.P./FILE: 2.2.9

Add. to reports dated [illegible], [illegible], & 10-22-68 E & M Laboratories, Circulators-switches for: Duane Hemphill, Ext: 3875

E.P. 39-7486

I. Thru Loss and Isolation

CIRCULATOR	FREQ. GHz	THRU LOSS BETWEEN PORT: 1 AND 2	THRU LOSS BETWEEN PORT: 1 AND 3	ISOLATION BETWEEN PORT: 1 AND 2	ISOLATION BETWEEN PORT: 1 AND 3
1	2.2	0.64 dB	0.60 dB	21.6	24.0
1	2.3	0.65	0.61	20.2	20.8
2	2.2	0.69	0.59	29.1	25.0
2	2.3	0.73	0.65	26.1	29.8
3	2.2	0.73	0.59	>30	18.8
3	2.3	0.62	0.55	21.2	23.1
4	2.2	0.61	0.57	28.5	26.1
4	2.3	0.57	0.59	19.6	30.2
5	2.2	0.63	0.60	>30	18.7
5	2.3	0.63	0.63	21.8	20.7
6	2.2	0.48	0.53	[illegible]	[illegible]
6	2.3	0.52	0.52	>30	22.6
7	2.2	0.58	0.56	28.1	22.0
7	2.3	0.60	0.60	21.4	20.2
8	2.2	0.55	0.63	17.0	19.7
8	2.3	0.61	0.61	21.7	19.3

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Paul J. Wright MSL Section HF/Microwave

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S. 106-24 Ext. 2814/3903

COLLINS RADIO CO., CEDAR RAPIDS, IA.

Date 1-29-69 W P/File No. 2.2.9

Addn. to reports dated 12-4-63, 10-22-68, 9-3-63, & 7-18-68. E&M Laboratories, Cir-switches for: Duane Hemphill, ext.3815, E.P. 39-7486

40 [illegible]

Thru Loss And Isolation

Circulator	Freq. GHz	Thru Loss Between Port: 1 and 2	Thru Loss Between Port: 1 and 3	Isolation Between Po[rt:] 1 and 2	Isolation Between Po[rt:] 1 and 3
1	2.2	0.62dB	0.60dB	22.1dB	22.2dB
1	2.3	0.63	0.59	20.5	20.2
2	2.2	0.69	0.59	29.1	26.5
2	2.3	0.73	0.64	25.6	29.6
3	2.2	0.63	0.58	>30	18.6
3	2.3	0.58	0.55	21.4	23.0
4	2.2	0.59	0.57	28.2	25.9
4	2.3	0.56	0.60	19.7	>30
5	2.2	0.65	0.60	>30	18.8
5	2.3	0.61	0.61	21.8	20.9
6	2.3	0.49	0.53	23.8	26.1
6	2.3	0.50	0.54	>30	22.5
7	2.2	0.58	0.57	27.3	21.8
7	2.3	0.59	0.60	21.2	20.3
8	2.2	0.57	0.62	17.1	19.6
8	2.3	0.53	0.55	21.4	19.1

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S. 106-24 Ext. 2814/3903

COLLINS RADIO CO., CEDAR RAPIDS, IA.

Date 3-21-69	W.P/File No. [illegible]
Addn. to reports dated 1-[illegible]-6[illegible], 1-4-68,	
10-22-68, 9-3-68, & 7-18-68, [illegible] Laborat[illegible]	
Circulator-Switches FOR: Duane Hemphill	
Ext. 3815, SP 59-7486	

5000 [illegible]

I. Thru Loss and Isolation

CIRCULATOR	FREQ. GHz	THRU LOSS BETWEEN PORT 1 and 2	THRU LOSS BETWEEN PORT 1 and 3	ISOLATION BETWEEN PORT 1 and 2	ISOLATION BETWEEN PORT 1 and 3
1	2.2 dB	0.63 dB	0.59 dB	22.7 dB	21.1 dB
1	2.3	0.64	0.60	19.8	20.2
2	2.2	0.70	0.61	29.8	24.5
2	2.3	0.75	0.67	25.9	29.7
3	2.2	0.67	0.57	>30	18.8
3	2.3	0.62	0.56	21.2	23.0
4	2.2	0.59	0.55	28.7	25.8
4	2.3	0.60	0.58	19.6	>30
5	2.2	0.63	0.60	>30	18.6
5	2.3	0.64	0.66	22.2	20.2
6	2.2	0.45	0.51	23.7	25.8
6	2.3	0.50	0.53	>30	22.4
7	2.2	0.54	0.54	27.5	21.8
7	2.3	0.57	0.58	21.3	20.3
8	2.2	0.49	0.57	17.0	19.5
8	2.3	0.60	0.62	21.7	19.5

MEASUREMENTS DATA

METROLOGY STANDARDS LABORATORY
M.S. 106-24 Ext. 2814/3903

COLLINS RADIO CO. CEDAR RAPIDS, IA.

Date 5-29-69 W.P./File No 2.2.9

Addn. to reports dated 3-21-69, 1-29-69, 12-4-68, 10-22-68, 9-3-68, & 7-18-68.

E&M Laboratories, Circulator-Switches

For: D. Hemphill, X3815, EP 39-7486

A. Thru Loss and Isolation

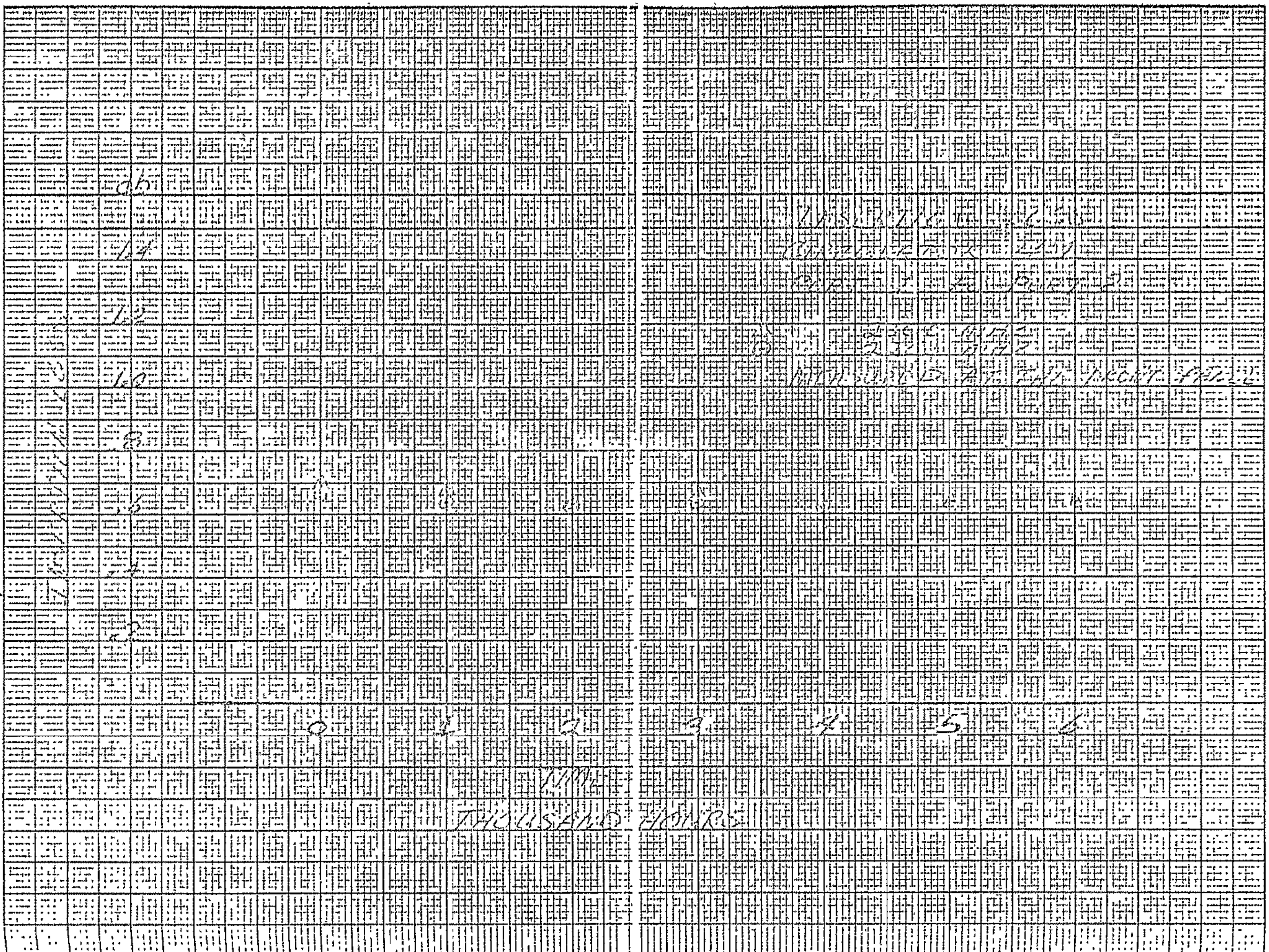
		THRU LOSS BETWEEN PORTS		ISOLATION BETWEEN PORTS	
CIRCULATOR	FREQ. GHz	1 - 2	1 - 3	1 - 2	1 - 3
1	2.2	0.63dB	0.59dB	21.1dB	22.0dB
1	2.3	0.68	0.63	20.3	19.9
2	2.2	0.72	0.66	28.7	22.9
2	2.3	0.78	0.69	26.4	22.8
3	2.2	0.75	0.61	>30	18.5
3	2.3	0.64	0.60	21.2	23.3
4	2.2	0.63	0.60	28.5	25.7
4	2.3	0.60	0.64	19.6	30
5	2.2	0.68	0.62	>30	18.1
5	2.3	0.64	0.67	20.4	20.2
6	2.2	0.52	0.56	24.0	25.6
6	2.3	0.54	0.54	>30	22.6
7	2.2	0.56	0.57	27.4	22.7
7	2.3	0.60	0.60	21.4	20.4
8	2.2	0.63	0.69	17.2	19.6
8	2.3	0.60	0.63	21.7	19.5

90

6000 hr (Final)

By William H. Franklin, Jr. MSL Section HF/Microwave

K&E 10 X 10 TO ½ INCH 46 1473
INCHES MADE IN U.S.A.
EL & ESSER CO.



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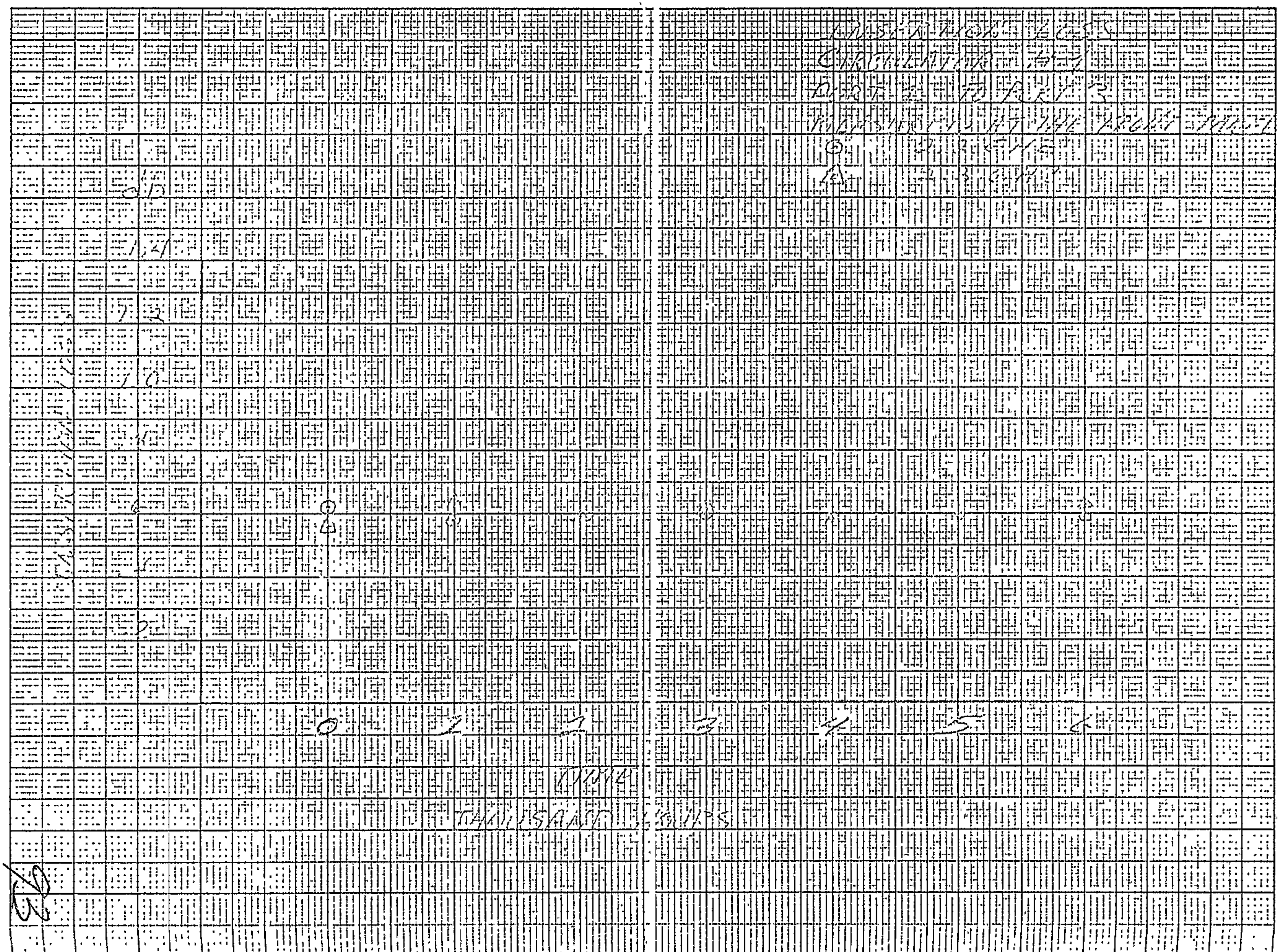
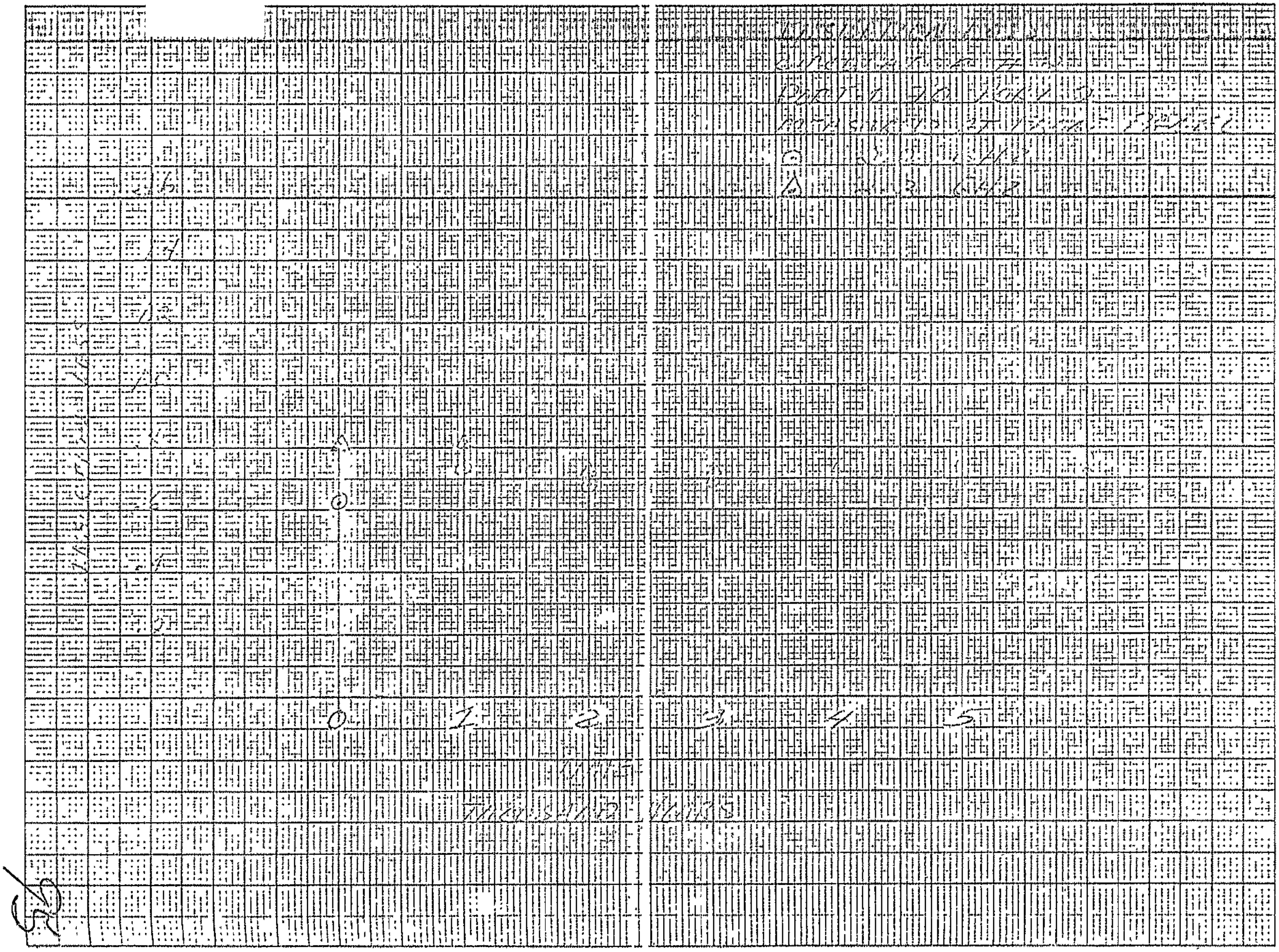

0 1 2 3 4 5 6
TIME

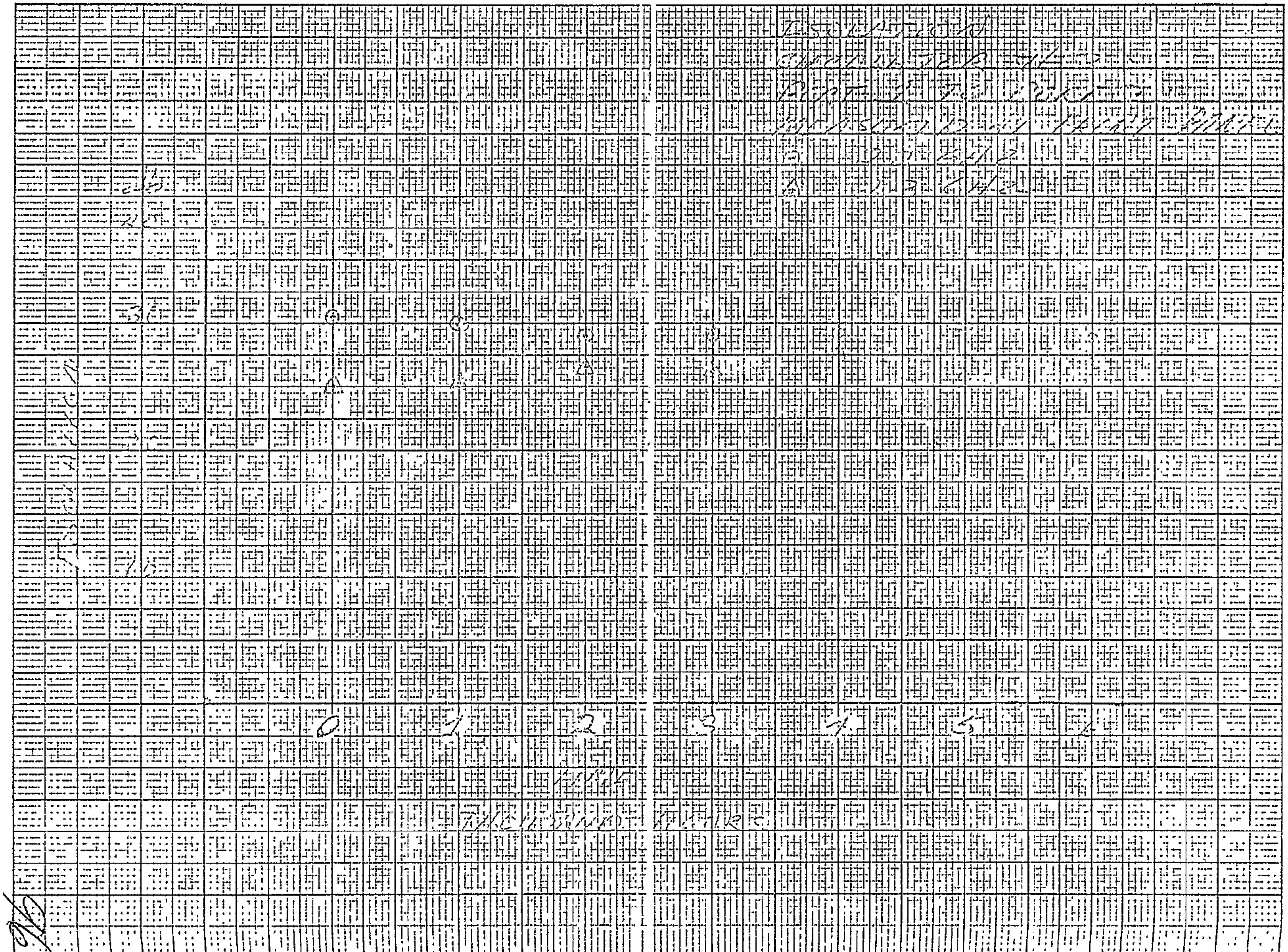
K+E 10 X 10 TO ½ INCH 46 1473
INCHES MADE IN U.S.A.
FFEL & ESSER CO.

0 1 2 3 4 5 6

THOUSAND HOURS

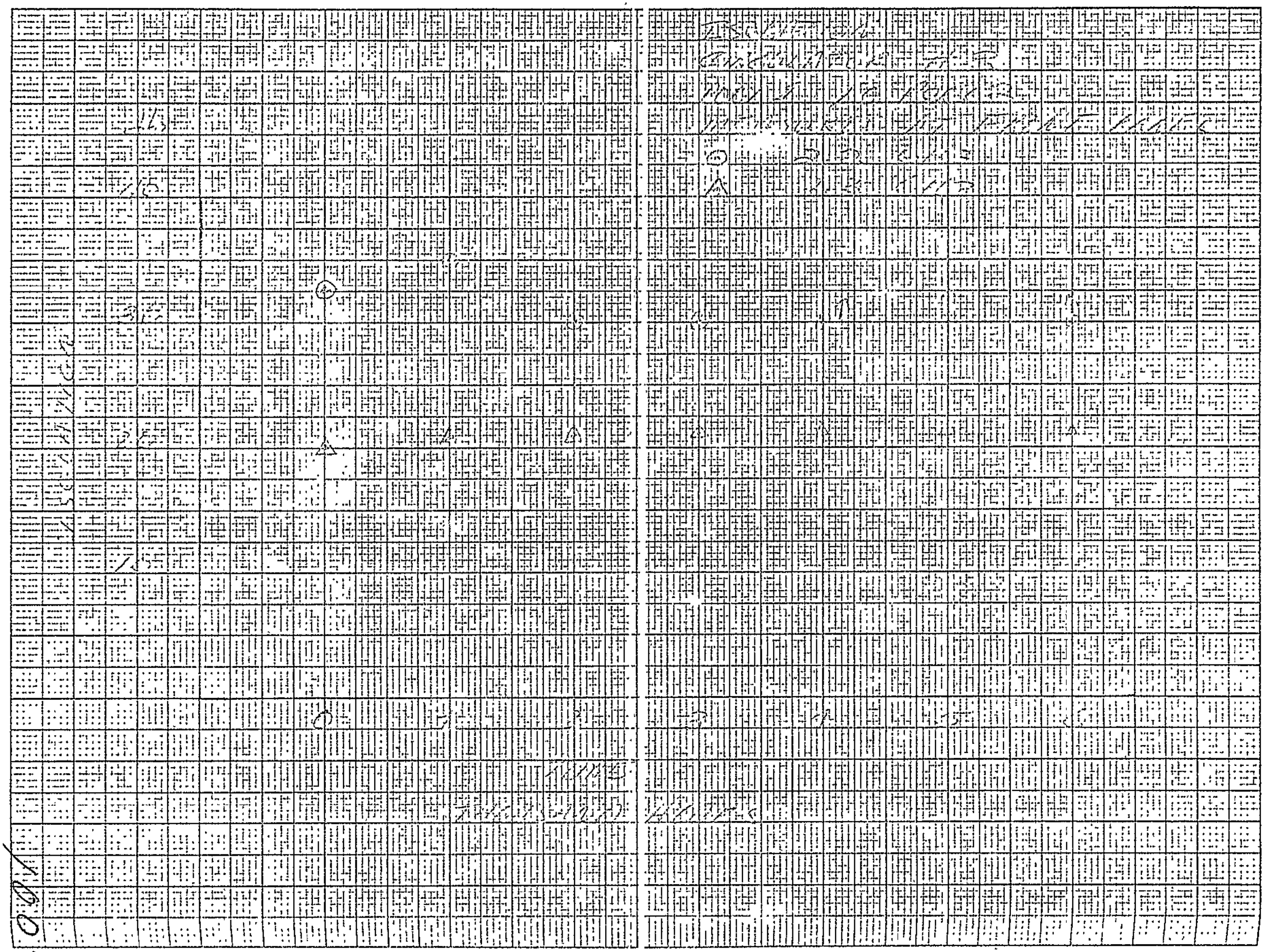

0
1
2
3
4
5

K+E 10 X 10 TO ½ INCH 46 1473
7″ INCHES MADE IN U.S.A.
'FEL & ESSER CO.



0 1 2 3 4 5

10 X 10 TO ½ INCH 46 1473
INCHES MADE IN U.S.A.
EL & ESSER CO.

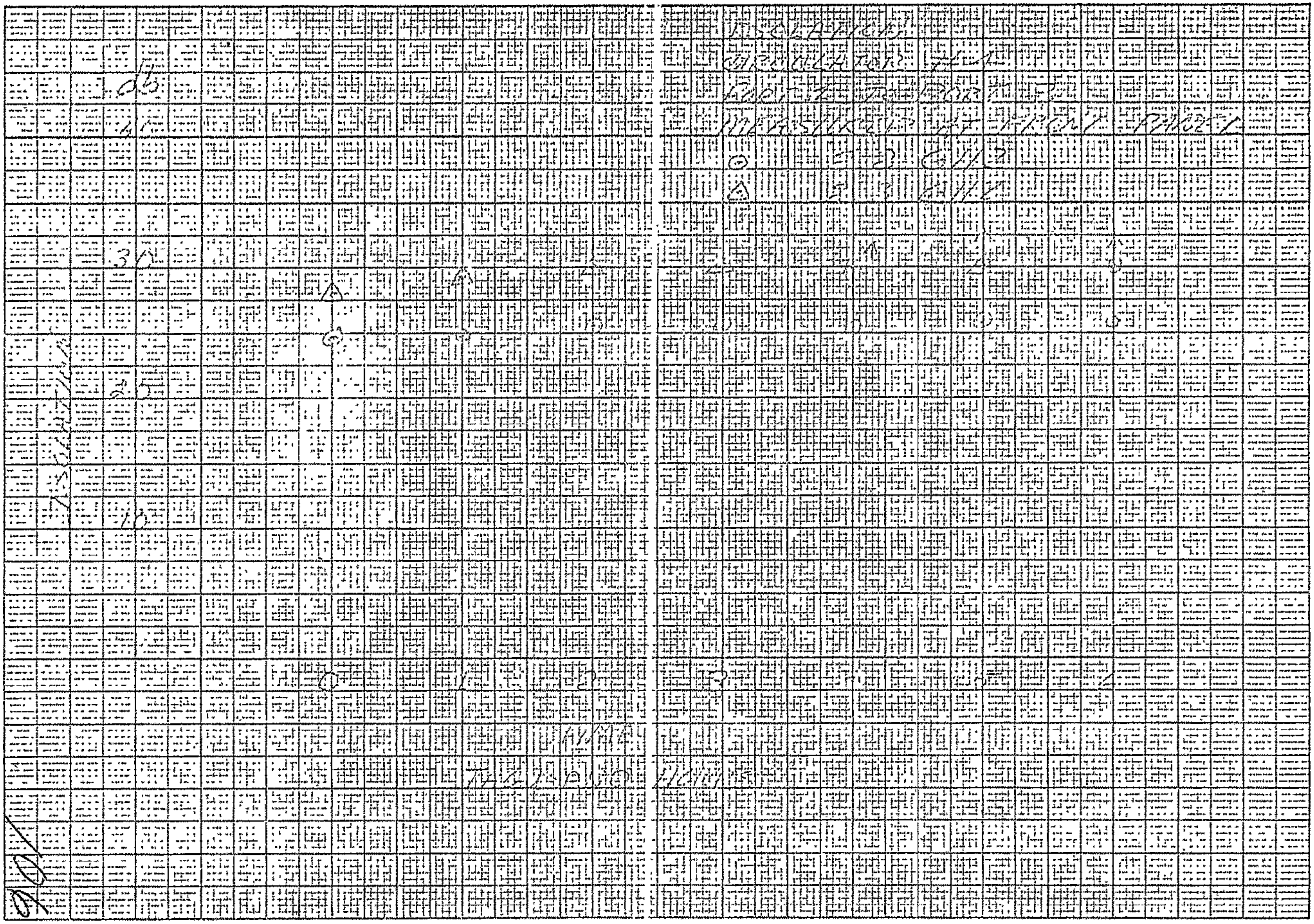


THOUSAND HOURS

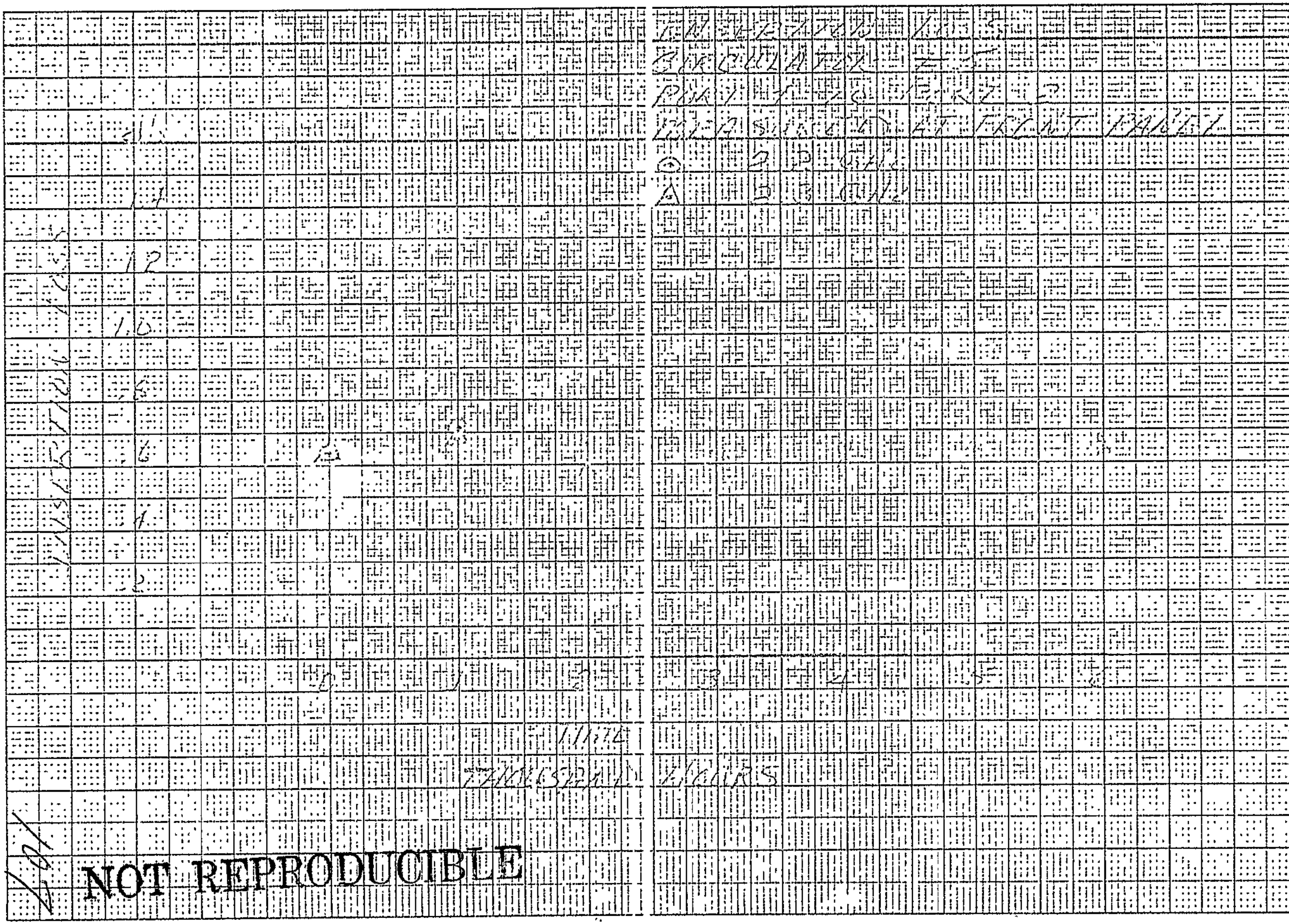
K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

K+E 10 X 10 TO ½ INCH 46 1473
7½ X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



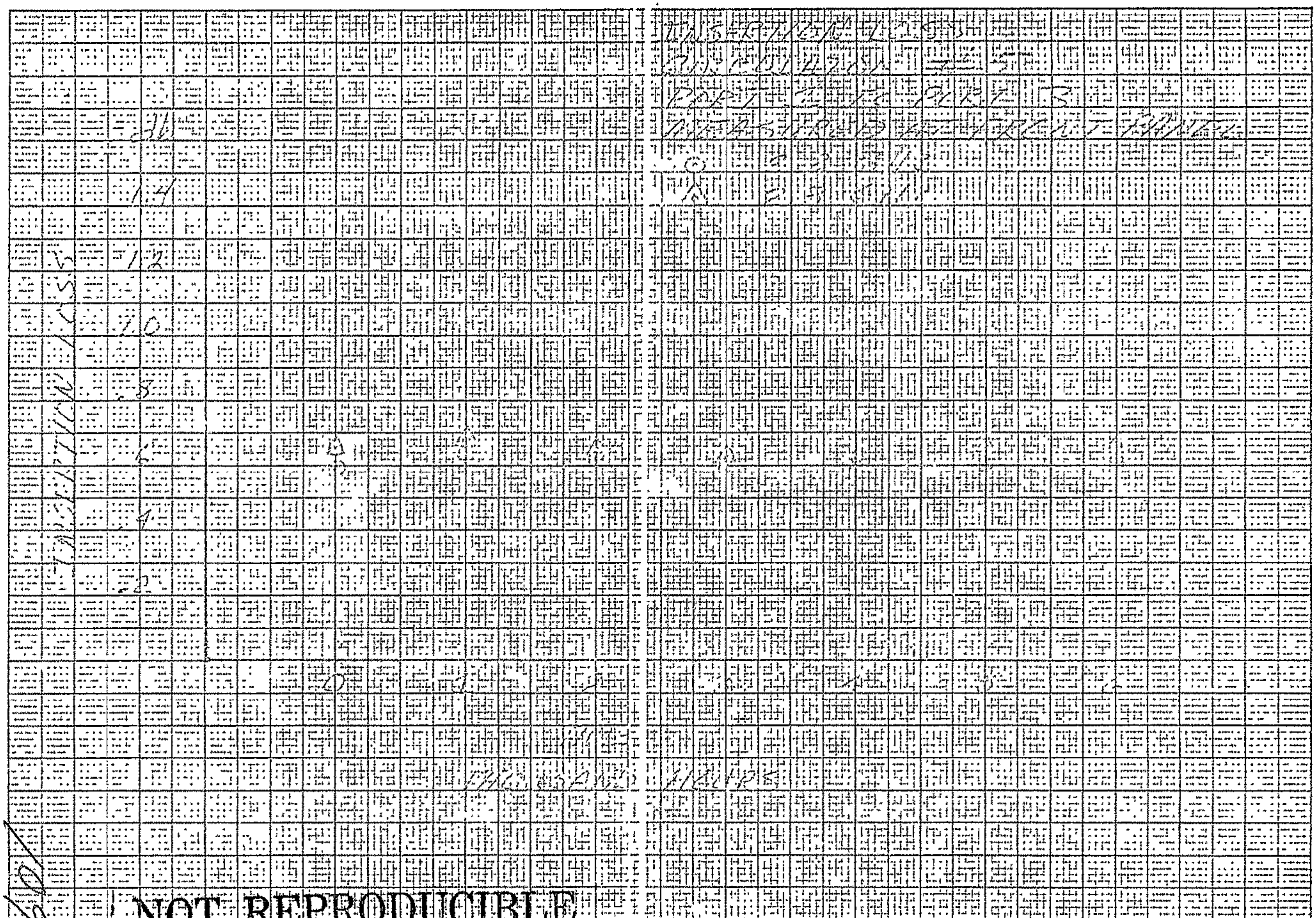
K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



101

46 1323
7 X 10 INCHES
MADE IN U.S.A.
K&E CO.

K+E 10 X 10 TO 1/2 INCH 46 1323.
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



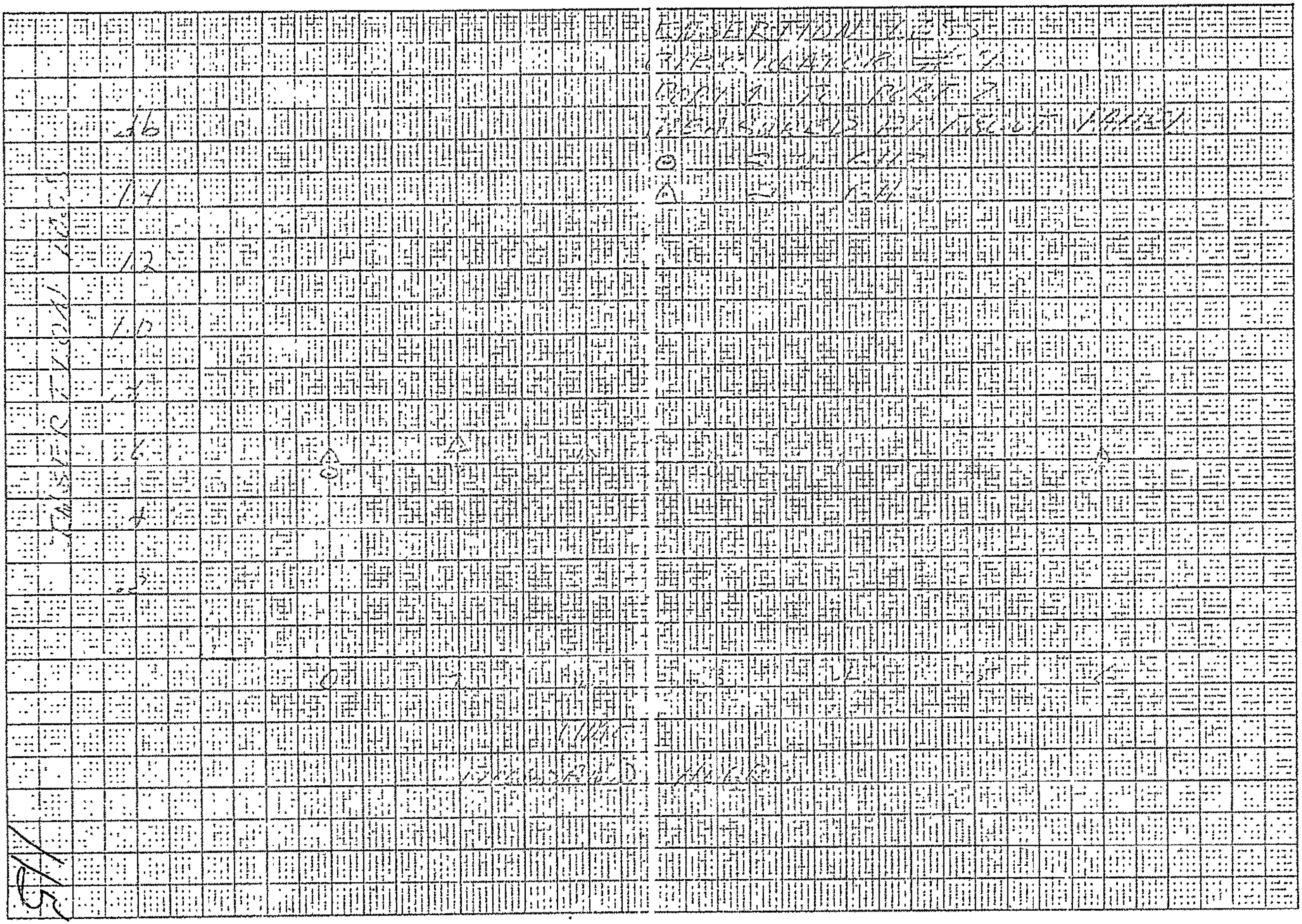
101

K&E 10 X 10 TO ½ INCH 46 1323
INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

K+E) TO ½ INCH 46 1323.
NCHES MADE IN U.S.A.
EUFFEL & ESSER CO.

K+E 10 X 10 TO ½ INCH 46 1323
MADE IN U.S.A.
EL & ESSER CO.


.16
.14
.12
.10
.08
.06
.04
.02
1/15

ISOLATION

40

30

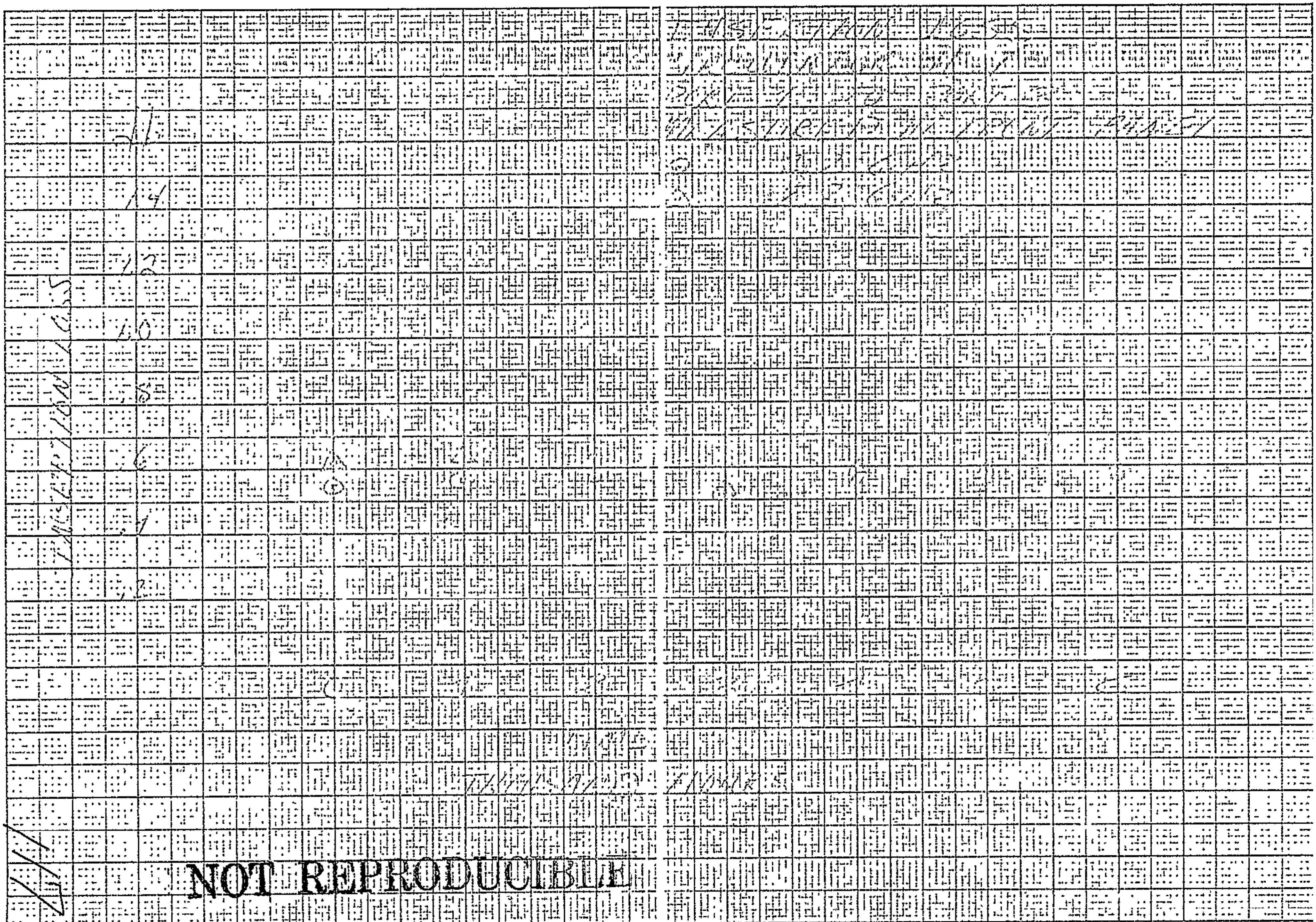
20

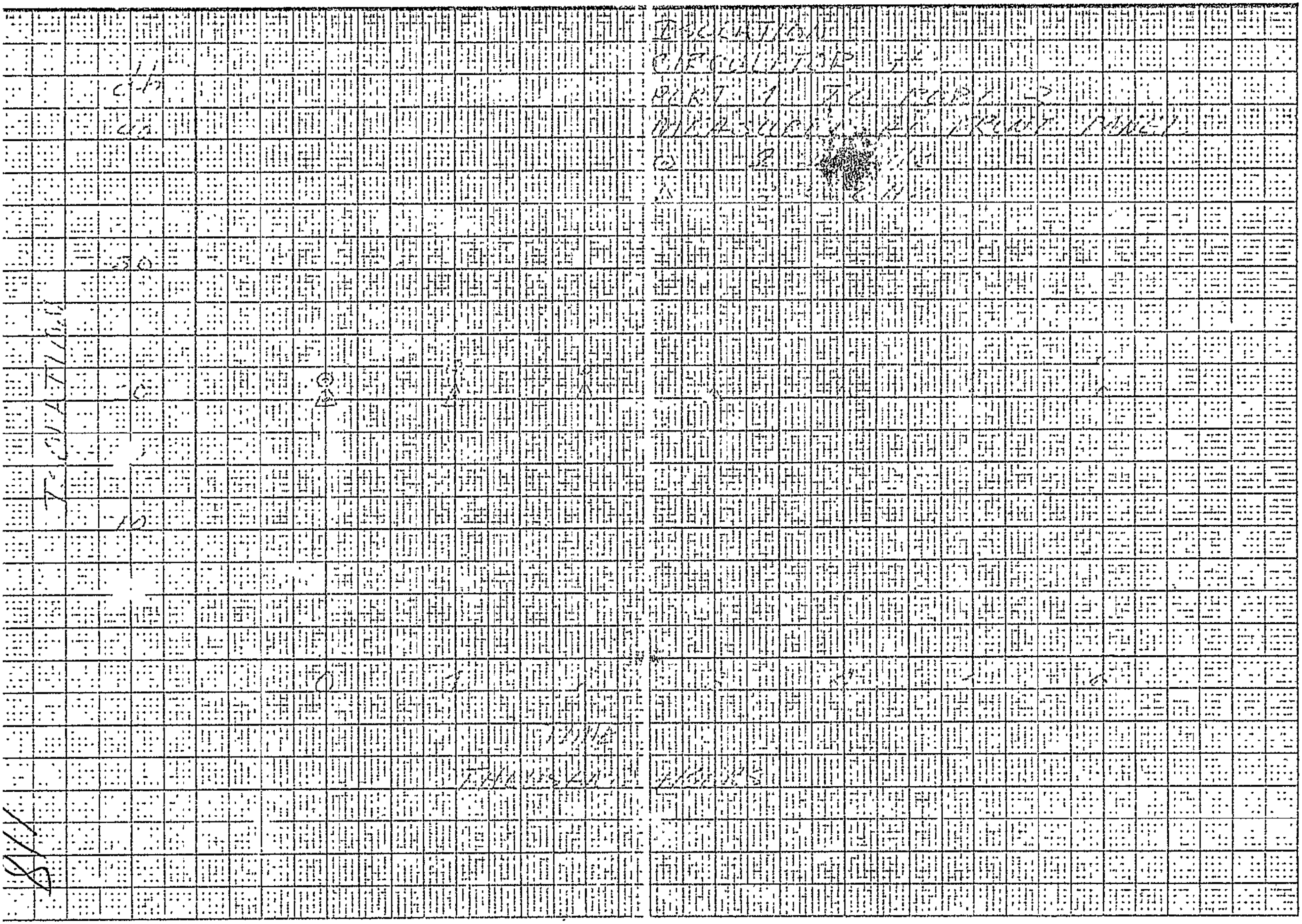
10

ISOLATION

116

K+E 10 X 10 TO ½ INCH 46 1323
MADE IN U.S.A.
KEUFFEL & ESSER CO.

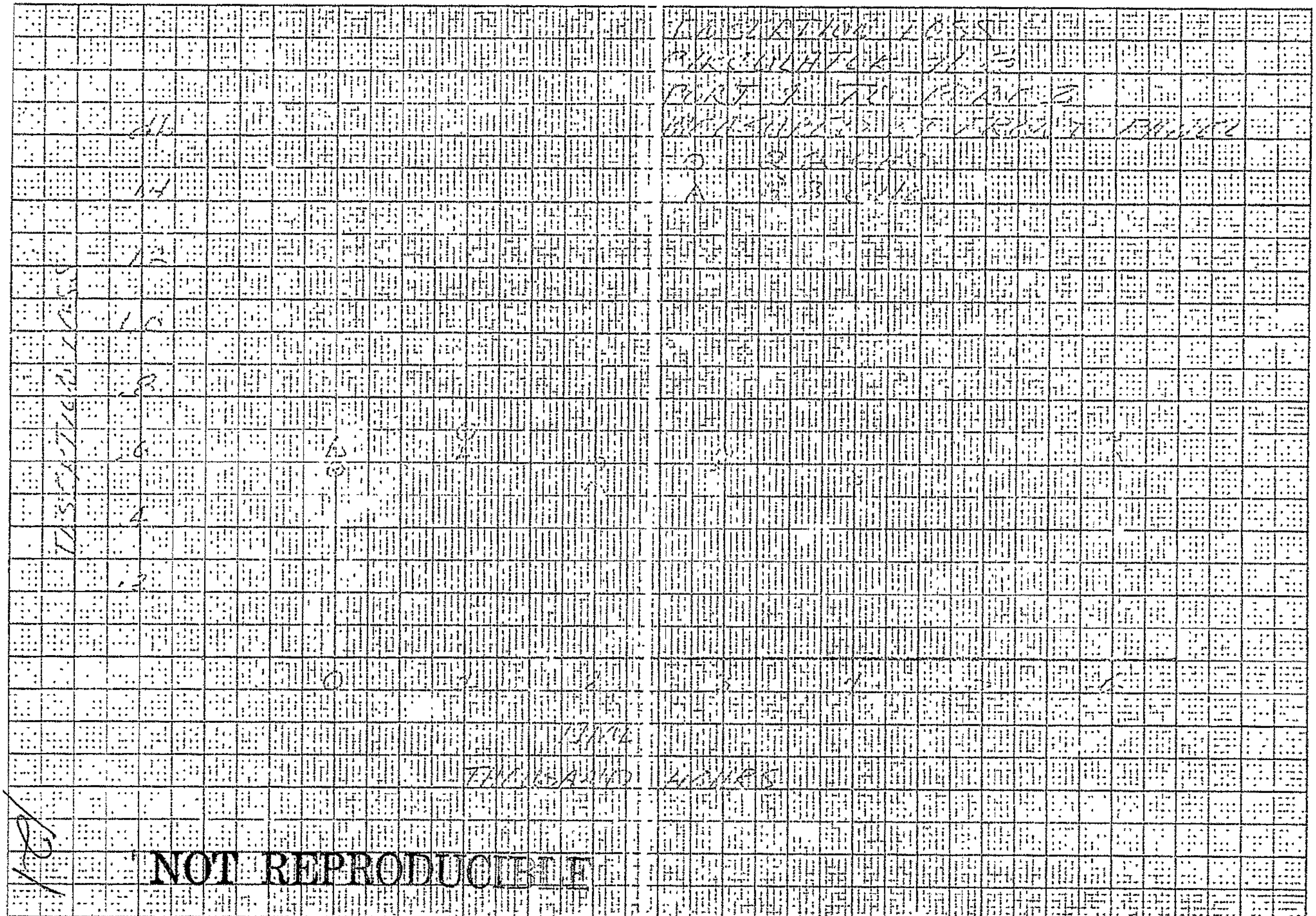



ELEVATION
-50
-10

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO

K&E 10 X 10 TO ½ INCH 46 1323
7 x 10 INCHES
KEUFFEL & ESSER CO.

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



APPENDIX B

ISOLATOR SWITCH SPECIFICATION

(044-0052-277)

044-0052-277

NOTICE:
1. INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327.
2. THE CLASS DESIGNATION AND THE SYMBOLS CAL, TA, CR, RA, SSA AND NSR WHICH MAY APPEAR ON THIS DRAWING ARE FOR INTERNAL USE ONLY BY THE COLLINS RADIO COMPANY AND ARE NOT RELATED TO THE ENGINEERING DATA CONTAINED HEREIN.
3. THE SYMBOL — IN THE REV STATUS BLOCK DENOTES ORIGINAL ISSUE.

DWG DATE 15 AUG 68

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	CORRECT TABLE 4 + 5	19AUG68	[illegible]
B	[illegible] 3.1.3, [illegible] Tables 3, 4, + 5.	20AUG68	[illegible]
C	SR 114462 at fig. 4 add mtg. hole pattern at fig 5 & 6 add material and finish.	4DEC68	R.B.P.
D	SR at 3.1.5.2.2 800 was 200	13JAN69	R.B.P.

1. SCOPE: THIS SPECIFICATION DEFINES THE REQUIREMENTS OF A TEN PORT COAXIAL FERRITE ISOLATOR-SWITCH IN ACCORDANCE WITH AND SUBJECTED TO THE CONDITIONS OF THIS SPECIFICATION. THIS COMPONENT PART IS FOR USE IN SPACE ELECTRONIC EQUIPMENT.

SUGGESTED SOURCES OF SUPPLY	CODE IDENT		VENDOR PN

REV STATUS OF SHEETS																								
REV	D	B	D	—	—	—	—	—	—	B	B	B	—	—	—	C	C	C						
SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

CLASS | CAL CHANGE DATE | SPECIFICATION CONTROL DRAWING | ENGRG PN 044-0052-277

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS± DECIMALS± ANGLES±

MATERIAL:

	NAME	DATE
PREP	[illegible]	15AUG68
CHK	D. Ott	8/15/68
PROJ	L. BALDWIN	31-7486 2660

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

ISOLATOR-SWITCH

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SIZE	CODE IDENT NO.	DWG NO.
A	13499	044-0052-277

SCALE | WT | SHEET 1 OF 18

074-6057-100 SPECIFICATION COMPONENT

2.0 APPLICABLE DOCUMENTS: THE FOLLOWING DOCUMENTS OF THE ISSUE IN EFFECT ON THE DATE OF INVITATION FOR BID, FORM A PART OF THIS SPECIFICATION, TO THE EXTENT SPECIFIED HEREIN.

MIL-STD-202	TEST METHODS FOR ELECTRONIC AND ELECTRICAL COMPONENT PARTS
QAP-100	COLLINS RADIO COMPANY, QUALITY ASSURANCE REQUIREMENTS FOR VENDORS.
074-0011-00	COLLINS RADIO COMPANY, QUALITY STANDARDS MANUAL.

3.0 REQUIREMENTS:

ELECTRICAL REQUIREMENTS:

3.1.1 GENERAL: THE ISOLATOR-SWITCH SHALL BE A TEN PORT COAXIAL DEVICE AS SHOWN SCHEMATICALLY IN FIGURE 2, PORTS 1,3,5,8 AND 9 WILL BE INPUT PORTS. PORTS 2,4,6,7, AND 10 WILL BE OUTPUT PORTS. JUNCTIONS (1), (2), (3), (4), (6), (8) SHALL BE SEMI-LATCHED CIRCULATOR SWITCHES DESIGNED TO PASS RF POWER IN ONE DIRECTION WHEN THE JUNCTION IS BIASED WITH A PERMANENT MAGNET AND TO PASS RF POWER IN THE OTHER DIRECTION WHEN JUNCTION BIASED WITH AN ELECTROMAGNET CIRCUIT. REMOVAL OF THE ELECTROMAGNETIC ENERGY SHALL CAUSE RF POWER TO PASS IN THE ORIGINAL DIRECTION. JUNCTIONS (5), (7) SHALL BE CIRCULATOR ISOLATORS EACH CONNECTED TO A LOAD.

3.1.2. FREQUENCY: THE ISOLATOR-SWITCH SHALL OPERATE OVER A FREQUENCY RANGE FROM 2100 MHz TO 2400 MHz.

3.1.3. INPUT POWER (RF): PORTS 5. 8 AND 9 SHALL BE TESTED WITH A CW INPUT POWER OF 20 WATTS MINIMUM 30 WATTS MAXIMUM. PORTS 1 AND 3 SHALL BE TESTED WITH A CW INPUT POWER OF 2 WATTS MAXIMUM.

3.1.4. LOADS: THE LOADS SHALL BE 50 OHM INTERNAL LOADS CAPABLE OF HANDLING 25 WATTS OF REFLECTED RF POWER.

3.1.5. SWITCHING:

5.1. JUNCTIONS (1), (2), (3), (4), (6) AND (8) OF THE ISOLATOR-SWITCH SHALL BE CAPABLE OF PASSING RF POWER AND BEING SWITCHED BY THE APPLICATION OF DC CURRENT AS OUTLINED IN TABLE 2.

3.1.5.1.1. JUNCTION (1) SHALL PASS POWER FROM PORT 1 TO PORT 2 WITHOUT THE APPLICATION OF DC CURRENT TO THE SWITCHING COIL. JUNCTION (1) SHALL BE CAPABLE OF BEING SWITCHED BY THE APPLICATION OF DC CURRENT TO PINS 1 AND 2. THE RF PATH WILL THEN BE FROM PORT 1 TO JUNCTION (2). UPON THE REMOVAL OF DC CURRENT FROM PINS 1 AND 2 JUNCTION (1) SHALL BE BIASED TO PASS RF POWER FROM PORT 1 TO PORT 2.

3.1.5.1.2. JUNCTIONS (2), (3), (4), (6) AND (8) SHALL HAVE SIMILAR SWITCHING CHARACTERISTICS TO THOSE OF JUNCTION (1) AS OUTLINED IN TABLE 2.

3.1.5.2. COIL:

3.1.5.2.1. NOMINAL COIL VOLTAGE: THE NOMINAL COIL VOLTAGE REQUIRED FOR PROPER OPERATION AT 25°C SHALL BE 7 VOLTS DC.

3.1.5.2.2. COIL POWER: THE COIL SHALL NOT REQUIRE MORE THAN 800 MILLI WATTS OF DC POWER, OVER THE TEMPERATURE RANGE SPECIFIED IN 3.3.1 WHEN OPERATED FROM A CONSTANT CURRENT SOURCE WITH CURRENT REGULATION OF ±1 MILLIAMPERE FROM THE NOMINAL CURRENT DEFINED BY THE SUBCONTRACTORS DESIGN.

3.1.6. VSWR:

3.1.6 PORT 1: WITH PORTS 2, 3 AND 4 TERMINATED IN A VSWR LOAD OF 1.3:1, THE VSWR PRESENTED BY THE ISOLATOR SWITCH SHALL NOT EXCEED 1.20:1 IN THE REGION FROM 2.2 GHz TO 2.3 GHz AND SHALL NOT EXCEED 1.25:1 ANYWHERE IN THE REGION FROM 2.1 GHz TO 2.4 GHz. THE SWITCH SHALL BE ENERGIZED PER TABLE 2.

3.1.6.2. VSWR MEASUREMENTS AND REQUIREMENTS FOR PORTS 3,5,8 AND 9 ARE PRESENTED IN TABLE 3. THE SWITCH SHALL BE ENERGIZED PER TABLE 2.

3.1.7. INSERTION LOSS:

3.1.7.1. PORT 1 TO PORT 2: THE TOTAL INSERTION LOSS, INCLUDING VSWR, BETWEEN PORTS 1 AND 2, SHALL NOT EXCEED 0.3 db ANYWHERE IN THE REGION BETWEEN 2.2 AND 2.3 GHz AND SHALL NOT EXCEED 0.35 db ANYWHERE IN THE REGION FROM 2.1 TO 2.4 GHz. THE SWITCH SHALL BE ENERGIZED PER TABLE 2.

3.1.7.2. INSERTION LOSS MEASUREMENTS AND REQUIREMENTS FOR THE OTHER RF PATHS ARE PRESENTED IN TABLE 4. THE SWITCH SHALL BE ENERGIZED PER TABLE 2.

REV

3.1.8. ISOLATION:

3.1.8.1. PORT 1 TO PORT 4: THE TOTAL ISOLATION BETWEEN PORT 1 AND PORT 4 SHALL BE NOT LESS THAN 36 db ANYWHERE IN THE REGION 2.1 TO 2.4 GHz. PORTS 2 AND 3 SHALL BE TERMINATED IN 1.3:1 VSWR LOAD. THE SWITCH SHALL BE ENERGIZED AS IN TABLE 2.

3.1.8.2. ISOLATION MEASUREMENTS AND REQUIREMENTS FOR THE OTHER RF PATHS ARE PRESENTED IN TABLE 5. THE SWITCH SHALL BE ENERGIZED PER TABLE 2.

3.1.9. RF IMPEDANCE: THE NOMINAL IMPEDANCE OF ALL PORTS SHALL BE 50 OHMS.

MECHANICAL REQUIREMENTS:

3.2.1. DIMENSIONS: DIMENSIONS ARE SHOWN IN FIGURE 4. ALL CHANGES IN DIMENSIONS, CONNECTOR LOCATIONS, OR MOUNTING SHALL BE COORDINATED WITH AND SUBJECT TO THE APPROVAL OF COLLINS RADIO COMPANY.

3.2.2. WEIGHT: THE TOTAL WEIGHT OF THE ISOLATOR-SWITCH SHALL NOT EXCEED 64 OUNCES.

3.2.3. MATERIAL AND FINISHES: THE MANUFACTURER SHALL BE RESPONSIBLE FOR THE SELECTION OF MATERIALS AND FINISHES COMPATIBLE WITH THE REQUIREMENTS OF THIS SPECIFICATION.

3.2.4. CONNECTORS: CONNECTORS SHALL BE GREMAR RED-LINE SERIES FEMALE OR EQUIVALENT.

3.2.5. MARKING: AS A MINIMUM, EACH UNIT SHALL BE LEGIBLY AND PERMANENTLY MARKED WITH MANUFACTURER'S NAME OR SYMBOL, COLLINS PART NUMBER, SERIAL NUMBER, PORT AND D-C CURRENT PIN IDENTIFICATION. THESE MARKINGS SHALL BE LEGIBLE FOLLOWING ALL TESTS.

3.2.6. PORT LOCATION: SEE FIGURE 2 AND FIGURE 3 FOR PORT LOCATION.

2.7. ADJUSTMENTS: THE REQUIREMENTS OF THIS SPECIFICATION SHALL BE FULFILLED AND MAINTAINED WITHOUT AN EXTERNALLY ACCESSIBLE ADJUSTMENT.

3.2.8. WORKMANSHIP: WORKMANSHIP SHALL CONFORM TO THE REQUIREMENTS OF COLLINS QUALITY STANDARDS MANUAL, 074-0011-00.

3.3. ENVIRONMENTAL REQUIREMENTS:

3.3.1. RF BREAKDOWN: THE ISOLATOR-SWITCH SHALL OPERATE AT FULL INPUT POWER IN AN ENVIRONMENT OF 760 MILLIMETERS OF HG AND SHALL BE FREE OF BREAKDOWN.

3.3.2. PHASE MODULATION: THE ISOLATOR-SWITCH SHALL NOT INTRODUCE MORE THAN 0.005 DEGREES RMS RESIDUAL PHASE MODULATION UNDER ANY OR ALL ENVIRONMENTAL CONDITIONS OR COMBINATION OF CONDITIONS SPECIFIED UNDER SECTION 3.3 OF THIS SPECIFICATION.

3.3.3. RADIATION INTERFERENCE: WITH 30 WATTS RF DRIVE POWER IN THE REGION OF 2200 TO 2300 MHz APPLIED TO THE ISOLATOR-SWITCH, THE RADIATED LEAKAGE FROM THE ISOLATOR SHALL NOT EXCEED 90 DB BELOW 1 WATT (-60 DBM).

3.3.4. MAGNETIC FIELDS: AS A DESIGN GOAL MAGNETIC FIELDS FROM PERMANENT OR ELECTRO MAGNETS SHALL BE CONFINED WITHIN THE PHYSICAL DIMENSIONS OF THE ISOLATOR-SWITCH.

3.3.5. OPERATING LIFE: THE ISOLATOR-SWITCH SHALL BE CAPABLE OF OPERATING FOR 10,000 HOURS.

3.3.6. SHELF LIFE: THE MINIMUM SHELF LIFE SHALL BE 5 YEARS.

3.3.7. TEMPERATURE RANGE:

3.3.7.1 OPERATING TEMPERATURE RANGE: 10°C TO 60°C (AMBIENT + MOUNTING PLATE TEMPERATURE)

3.3.7.2. NON-OPERATING (STORAGE TEMPERATURE RANGE): -40°C TO +85°C

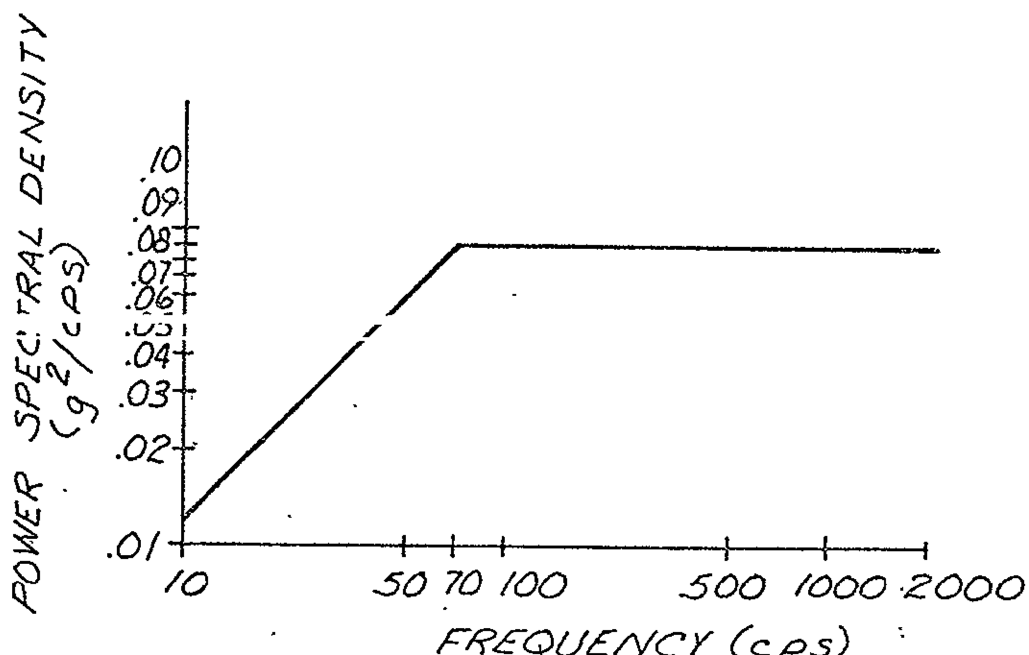
3.3.8. OPERATING PRESSURE CONDITION: 760 MILLIMETERS OF Hg

3.3.9. VIBRATION: THE UNIT SHALL MEET THE REQUIREMENTS OF PARAGRAPH 3.1 AND SHALL SHOW NO EVIDENCE OF PHYSICAL OR MECHANICAL DAMAGE DURING AND FOLLOWING SUBJECTION TO VIBRATION TESTS.

3.3.9.1. RANDOM VIBRATION: THE TEST SPECIMAN SHALL BE MOUNTED TO BRACKETS AS SHOWN IN FIGS. NO. 5 AND 6 AND THIS ASSEMBLY SHALL BE MOUNTED TO A 2 INCH THICK ALUMINUM FLAT PLATE. THE TEST SPECIMAN SHALL BE SUBJECTED TO RANDOM VIBRATION FOR A MINIMUM OF SIX MINUTES ALONG EACH OF THE THREE ORTHOGONAL AXES AS FOLLOWS:

REV

RANGE	POWER SPECTRAL DENSITY LEVEL
10 TO 70 CPS	LINEAR INCREASE FROM $.012g^2$/CPS TO $.09g^2$/C (LINEAR REFERS TO A STRAIGHT LINE ON LOG-LOG PAPER)
70 TO 2000 CPS	CONSTANT AT $.09g^2$/CPS



RANDOM VIBRATION TEST LEVEL

TOLERANCES: ±3DB ON SPECTRAL DENSITY AT ANY FREQUENCY.
OVERALL g_{rms} LEVEL: $13.5g_{rms}$ ±10%

(NOTE: VIBRATION TESTING TO BE DONE BY CRC IN CEDAR RAPIDS)

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SIZE	CODE IDENT NO.	DWG. NO.	
A	13499	044-0052-277	
SCALE NONE	WT	SEE SHEET 1	SHEET 6

SHOCK: NOT APPLICABLE.

TEMPERATURE CYCLING: THE UNIT SHALL MEET THE REQUIREMENTS OF PARAGRAPH 3.1 AND THERE SHALL BE NO EVIDENCE OF PHYSICAL OR MECHANICAL DAMAGE FOLLOWING SUBJECTION TO TEMPERATURE CYCLING PER MIL-STD-202 METHOD 102 EXCEPT TEMPERATURE LIMITS OF PARA. 3.3.7.2.

TOXIC FUMES OR VAPORS: NO TOXIC FUMES OR VAPOR SHALL BE PRODUCED UNDER ANY COMBINATION OF TEST CONDITIONS SPECIFIED HEREIN.

HUMIDITY: THE UNIT SHALL MEET THE REQUIREMENTS OF PARAGRAPH 3.1 AND THERE SHALL BE NO EVIDENCE OF PHYSICAL OR MECHANICAL DAMAGE FOLLOWING SUBJECTION TO HUMIDITY PER MIL-STD-202 METHOD 103 TEST CONDITION B. POLARIZATION VOLTAGE IS NOT APPLICABLE.

QUALITY ASSURANCE:

ACCEPTANCE INSPECTION:

SCREENING ACCEPTANCE: PRIOR TO SHIPMENT, EACH UNIT SHALL BE SCREENED BY SUBJECTING EACH UNIT TO THE TESTS AND CONDITIONING SPECIFIED IN ;ABLE 1. UNITS NOT CONFORMING SHALL BE REJECTED. TEST DATA WITH PART IDENTIFICATION SHALL BE INCLUDED WITH THE SHIPMENT OF THE UNIT. TEST DATA SHALL BE IN THE FORM OF ACTUAL VALUES OBSERVED AND RECORDED.

TABLE 1

ACCEPTANCE INSPECTION

TEST OR CONDITIONING	REF. PARA.	TEST REQUIREMENTS
VISUAL AND MECHANICAL	3.2	
SWITCHING	3.1.5	A & B
VSWR	3.1.6	A & B
INSERTION LOSS	3.1.7	A & B
ISOLATION	3.1.8	A & B

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TEST REQUIREMENTS

A: ACCEPTANCE INSPECTION MAY BE PERFORMED OVER THE RANGE 2.2 TO 2.3 GHz ONLY. SUFFICIENT DATA TO INSURE COMPLIANCE TO THESE REQUIREMENTS MUST BE PROVIDED.

B: THE SEQUENCE OF THE ELECTRICAL TESTING MAY BE DETERMINED BY THE SUPPLIER. HOWEVER, AN ACCEPTANCE TEST PROCEDURE SHALL DICTATE THE TEST SEQUENCE.

C: THE TESTS, LISTED IN TABLE 1 ABOVE, ARE THE MINIMUM REQUIREMENTS FOR VERIFICATION OF COMPLIANCE TO THIS SPECIFICATION. HOWEVER, REQUIREMENTS NOT SPECIFICALLY CALLED OUT ARE NOT TO BE CONSTRUED AS WAIVERED, AND THE SUBCONTRACTOR SHALL BE RESPONSIBLE FOR COMPLIANCE TO ALL REQUIREMENTS FOR SECTION 3 OF THIS SPECIFICATION.

D: COLLINS RADIO CO. RESERVES THE RIGHT TO PERFORM ANY AND ALL TESTS TO CONFIRM COMPLIANCE WITH THIS SPECIFICATION AND WITH THE VENDOR HAVING THE PRIVILEGE TO WITNESS SUCH TESTS. DATA RECEIVED FROM THESE TESTS SHALL BE SUPPLIED TO THE VENDOR.

PREPARATION FOR DELIVERY:

PACKAGING: THE UNITS SHALL BE INDIVIDUALLY PACKAGED IN SUCH A MANNER THAT THEY WILL BE PROTECTED DURING SHIPMENT AND HANDLING.

PACKING: UNITS, PACKAGED AS SPECIFIED, SHALL BE PACKED IN CONTAINERS OF THE TYPE, SIZE AND KIND COMMONLY USED FOR THE PURPOSE, AND A MANNER THAT WILL ENSURE ACCEPTANCE BY COMMON CARRIER AND SAFE DELIVERY AT DESTINATION.

NOTES: THIS SECTION IS NOT APPLICABLE TO THIS SPECIFICATION.

TABLE 2

RF POWER SWITCHING

Switch Mode	RF Power Direction	DC Voltage on pins + -
1	Port 1 to Port 2	None
2	Port 1 to Port 4	1-2 3-4
3	Port 3 to Port 4	None
4	Port 3 to Port 2	1-2 3-4
5	Port 5 to Port 7	None
6	Port 5 to Port 6	5-6
7	Port 8 to Port 7	7-8
8	Port 8 to Port 10	9-10 11-12
9	Port 9 to Port 7	7-8 9-10 11-12
10	Port 9 to Port 10	None

SIZE A | CODE IDENT NO. 13499 | DWG. NO. 044-0052-372

SCALE NONE | WT | SEE SHEET 1 | SHEET 9

REV

TABLE 3

VSWR MEASUREMENTS

Port	VSWR Requirement 2.2 - 2.3 GHz	VSWR Requirement 2.1 - 2.4 GHz	Switch Mode - Table 2	Terminations Port	Terminations VSWR Load
1	1.20:1	1.25:1	[illegible]	2,3,4	1.3:1
3	"	"	[illegible]	1,2,4	"
1	"	"	[illegible]	2,3,4	"
3	"	"	[illegible]	1,2,4	"
5	"	"	[illegible]	6,7,8,9,10	"
5	"	"	[illegible]	6,7,8,9,10	"
8	"	"	[illegible]	5,6,9,7,10	1.3:1 Short Variable all phase
9	"	"	0	5,6,7,8,10	"
8	"	"	[illegible]	5,6,9,7,10	"
9	"	"	[illegible]	5,6,7,8,10	"

TABLE 4

INSERTION LOSS

RF Path (Port to Port)	Insertion Loss Requirement		Switch Mode (Table 2)
	2.2 - 2.3 GHz	2.1 - 2.4 GHz	
1 to 2	NMT 0.3 db	NMT 0.35 db	1
3 to 4	0.3	0.35	3
1 to 4	0.6	0.7	2
3 to 2	0.6	0.7	4
5 to 7	0.6	0.7	5
5 to 6	0.3	0.35	6
8 to 7	0.7	1.05	7
9 to 10	0.6	0.7	10
8 to 10	0.7	1.05	8
9 to 7	1.0	1.4	9

TABLE 1

ISOLATION

RF Path (Port to Port)	Isolation Path (Port to Port)	Isolation Requirement 2.1-2.4 GHz	Switch Mode (Table 2)	Terminations Port	Terminations VSWR Load
1 to 2	1 to 4	NLT 36 db	1	2,3	1.3:1
3 to 4	3 to 2	36	3	1,4	
1 to 4	1 to 2	18	2	3,4	
3 to 2	3 to 4	18	4	1,2	
5 to 7	5 to 6	18	5	7,8,9,10	
5 to 6	5 to 7	36	6	6,8,9,10	
8 to 7	8 to 10	NLT 36 db	7	5,6,7,9	
8 to 7	8 to 9	36	7	5,6,7,10	
8 to 7	8 to 6	36	7	5,7,9,10	
8 to 7	8 to 5	18	7	6,7,9,10	
9 to 10	9 to 7	NLT 36 db	10	5,6,8,10	
9 to 10	9 to 8	36	10	5,6,7,10	
8 to 10	8 to 7	NLT 18 db	8	5,6,9,10	
8 to 10	8 to 9	36	8	5,6,7,10	
9 to 7	9 to 10	NLT 18 db	9	5,6,7,8	
9 to 7	9 to 8	36	9	5,6,7,10	

SIZE A | CODE IDENT NO. 13499 | DWG. NO. 044-2052-277

SCALE NONE | WT | SEE SHEET 1 | SHEET 12

REV B

REV

SOLID ARROW INDICATES DIRECTION OF RF PATH WHEN COIL IS DE-ENERGIZED.

DASHED ARROW INDICATED DIRECTION OF RF PATH WHEN COIL IS ENERGIZED.

POLARITY OF DC POWER TO BE APPLIED TO THE SWITCH INDICATED BY THE (+) AND (-) DESIGNATORS ON THE SCHEMATIC.

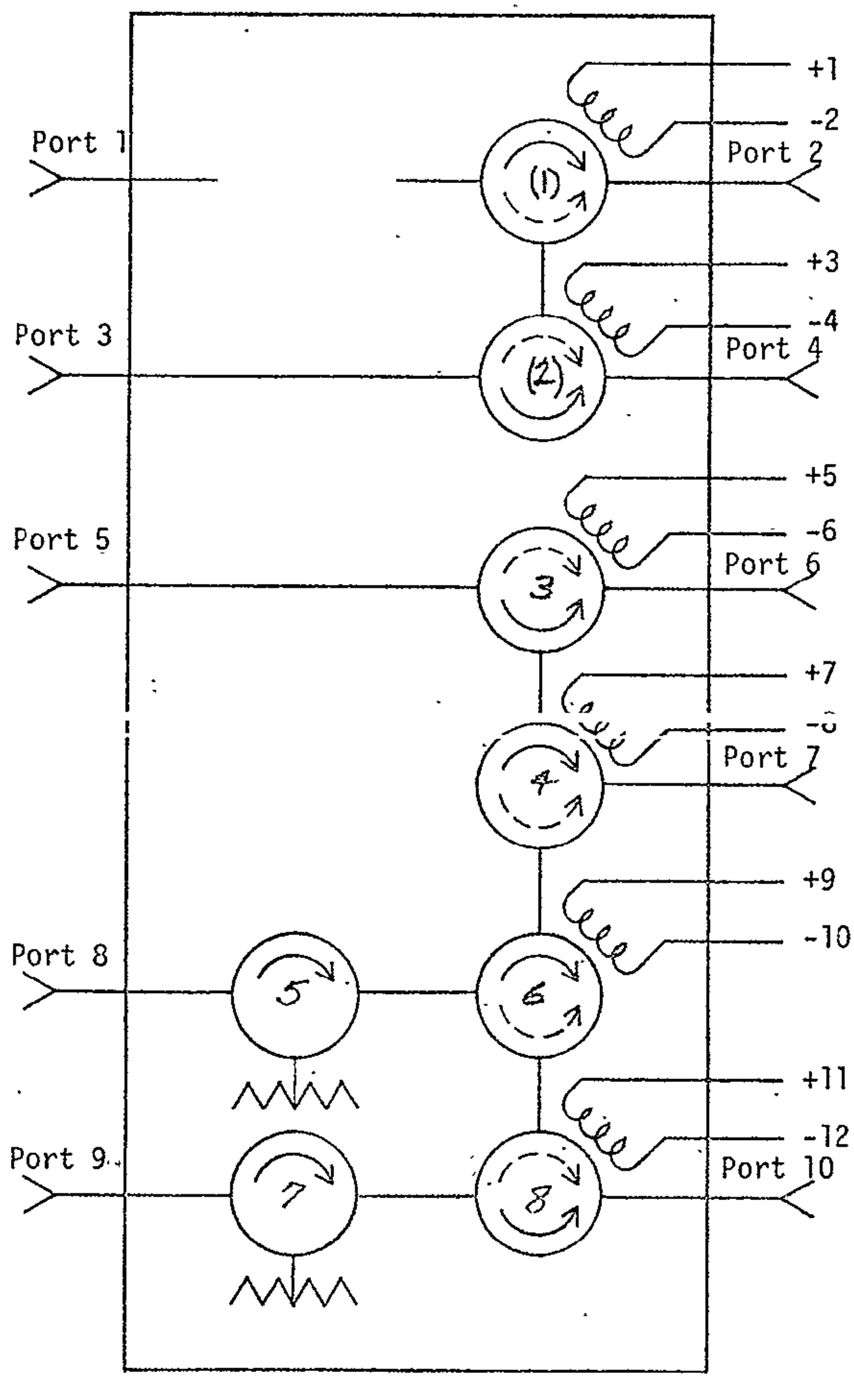

FIGURE I
SCHEMATIC DIAGRAM

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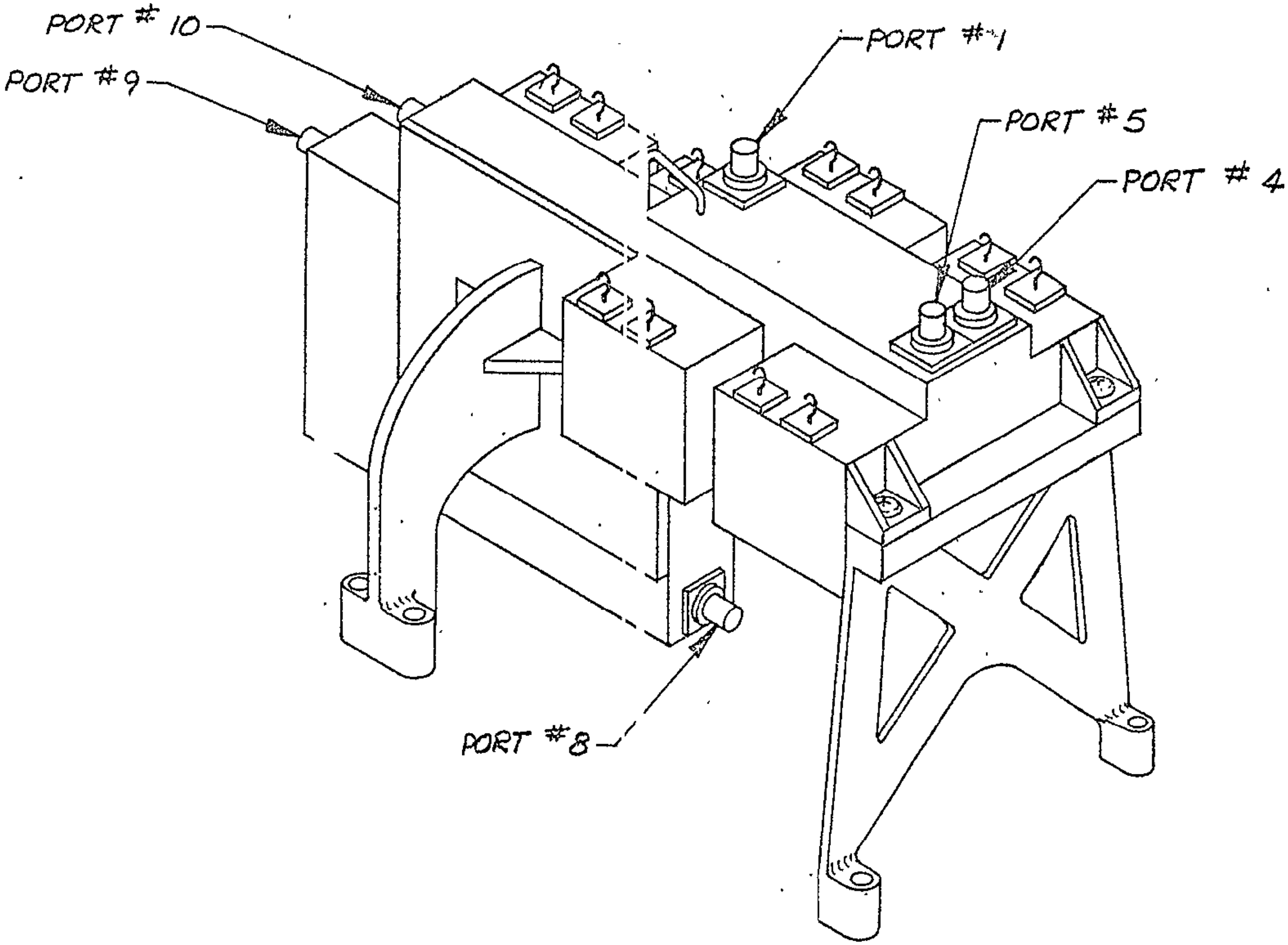
SIZE	CODE IDENT NO.	DWG. NO.
A	13499	C44-0052-277



Fig

SIZE	CODE IDENT NO.	DWG. NO.	REV
A	13499	C44-0052-277	
SCALE NONE	WT	SEE SHEET 1	SHEET 14

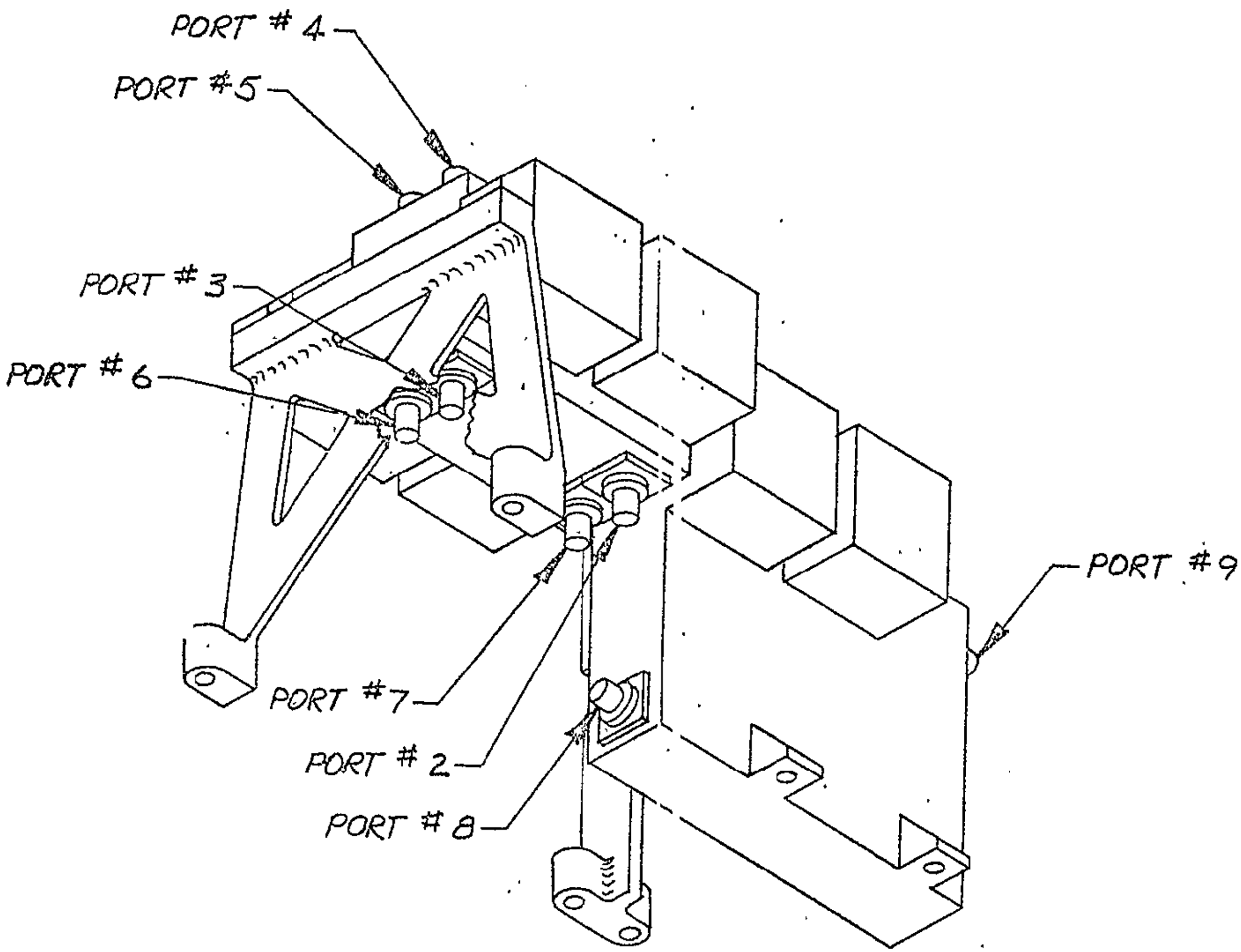


Fig. 3

SIZE A

CODE IDENT NO. 13499

DWG. NO. C44-0052-277

SCALE NONE

WT

SEE SHEET 1

SHEET 15

REV

38

FOLDOUT FRAME

NOTES: 1. ALL RADII $\frac{3}{32} \pm \frac{1}{32}$ UNLESS OTHERWISE SPECIFIED.

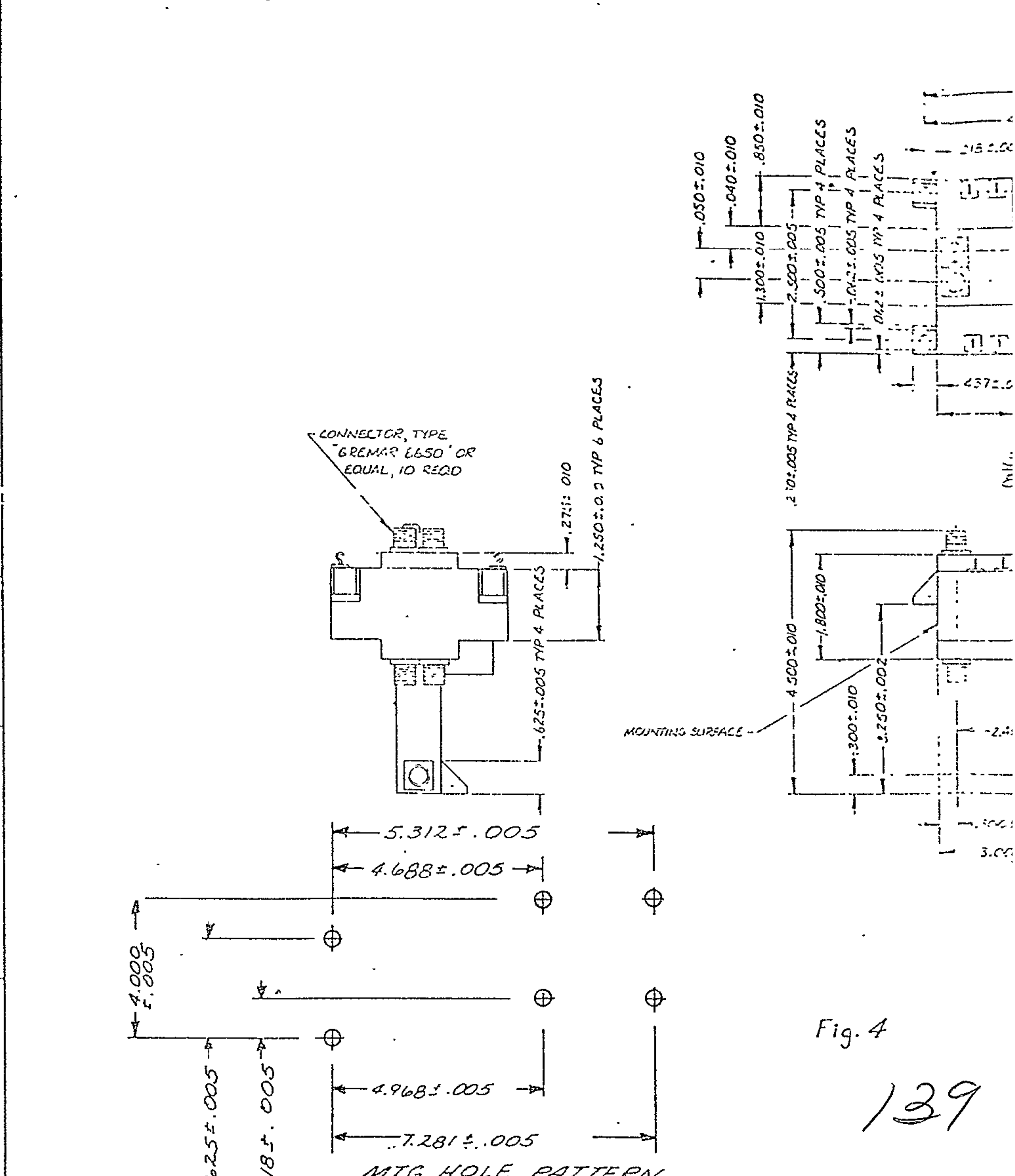


Fig. 4

139

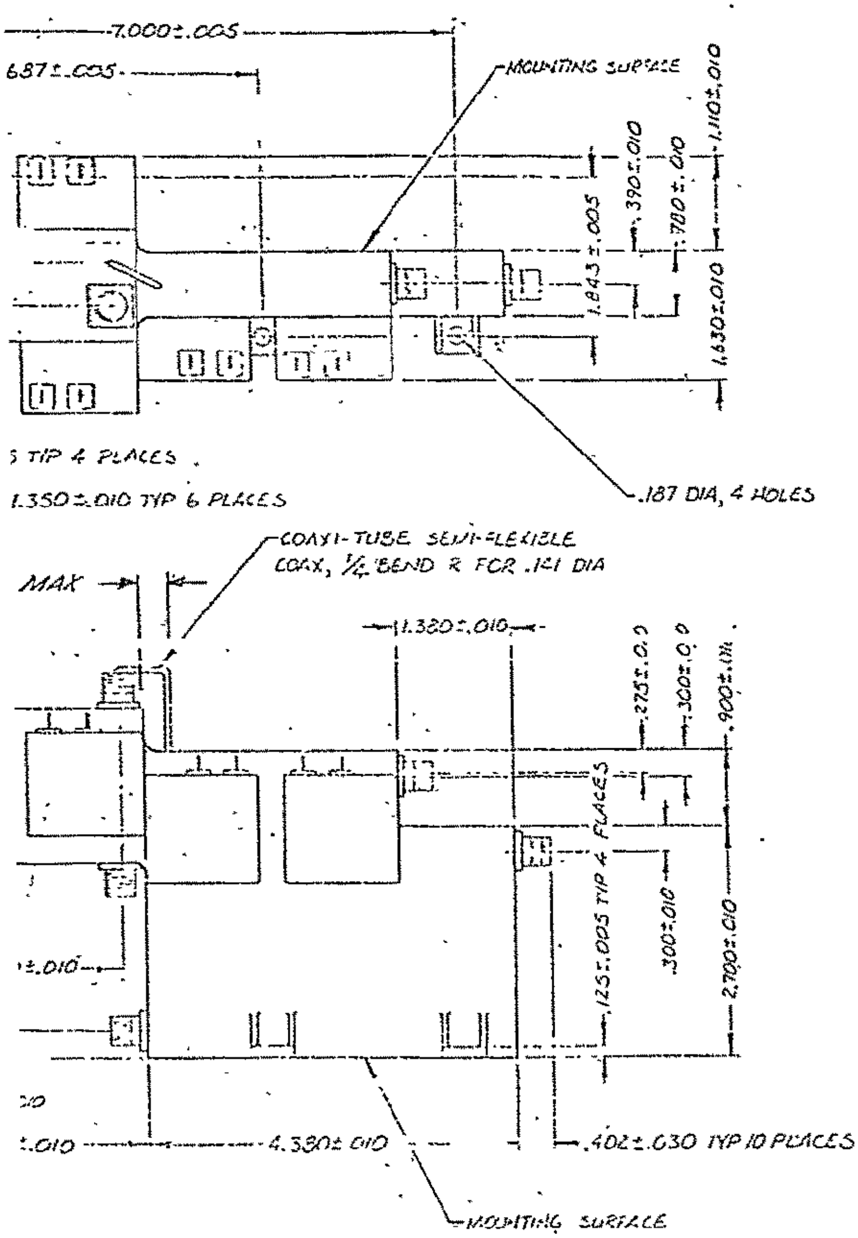
FOLDOUT FRAME

B

3	2	1

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	C			



QTY REQD	SYM	ITEM NO	COLLINS PART NO	PART OR IDENTIFYING NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	CODE IDENT

LIST OF MATERIAL OR PARTS LIST

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CONTRACT NO	COLLINS RADIO COMPANY CEDAR RAPIDS, IOWA
APPLIED FINISH	DECIMAL DIM ±.005 FRACTIONAL DIM ±1/64 DECIMAL HOLE DIA ±.005 MACHINED ANGLES ±0 1 SHEARED ANGLES ±0 25 FORMED ANGLES ±1 0	NAME / DATE: DR / CHK / APPD	Isolator - Switch
HEAT TREATMENT	ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 T R INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-70327		SIZE D · CODE IDENT NO 13499 · DWG NO 044-0052-279
			SCALE NONE · WT · SHEET 16

A 140

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
C			

NOTES.

1. ALL RADII 1/8 UNLESS OTHERWISE SPECIFIED.
2. FINISH: MIL-C-5541 CLASS 3 CHROMATE DIP.

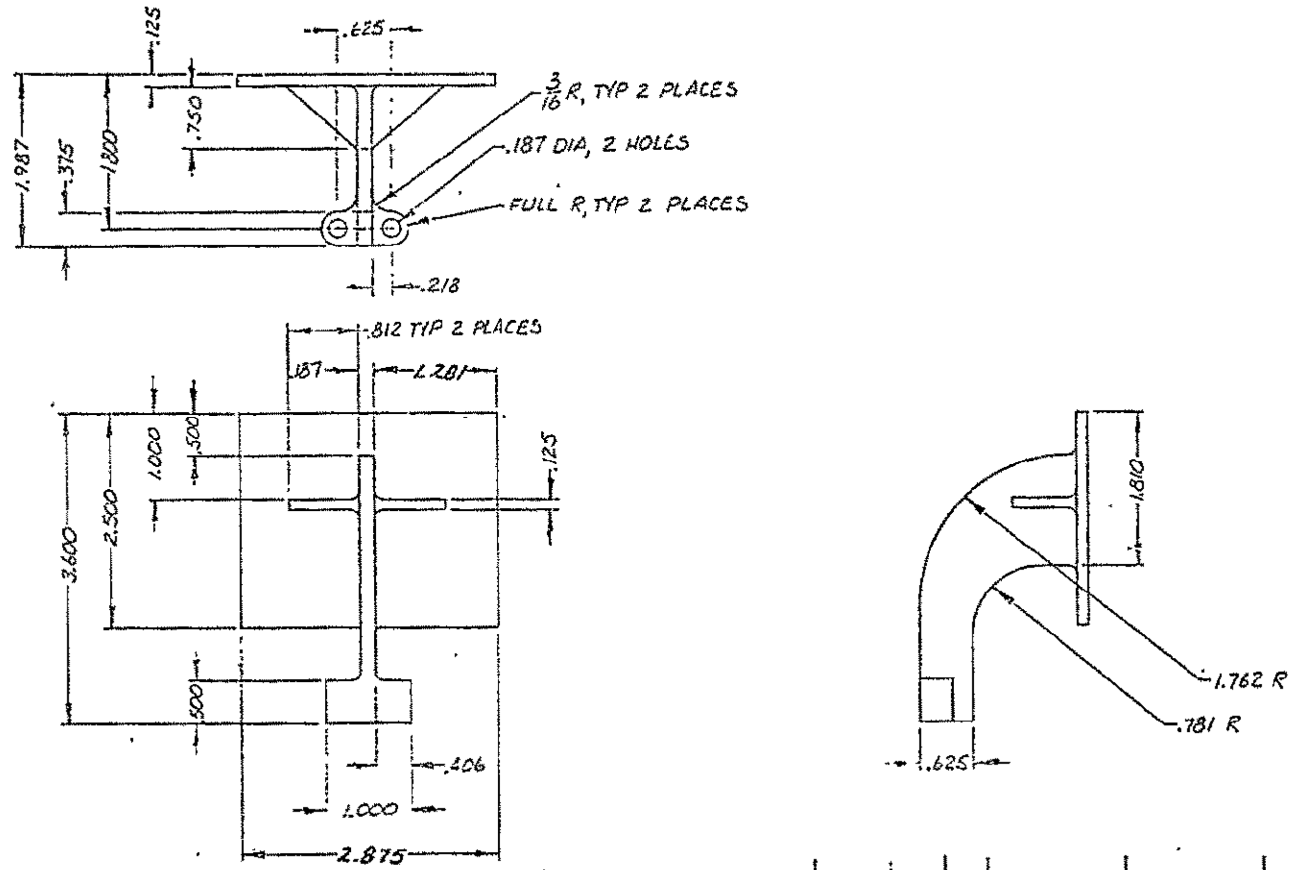


Fig. 5

QTY REQD	ITEM NO.	COLLINS PART NO	PART OR IDENTIFYING NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	CODE IDENT

LIST OF MATERIAL OR PARTS LIST

MATERIAL: 6061-T6 ALUM

APPLIED FINISH: SEE NOTE 2

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DECIMAL DIM. ± .005
FRACTIONAL DIM ± 1/64
DECIMAL HOLE DIA ± .005
MACHINED ANGLES ± 0 1
SHEARED ANGLES ± 0 25
FORMED ANGLES ± 1 0
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL—D—70327

CONTRACT NO.

	NAME	DATE
DR		
CHK		
APPD		

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

SWITCH BRACKET NO. 1

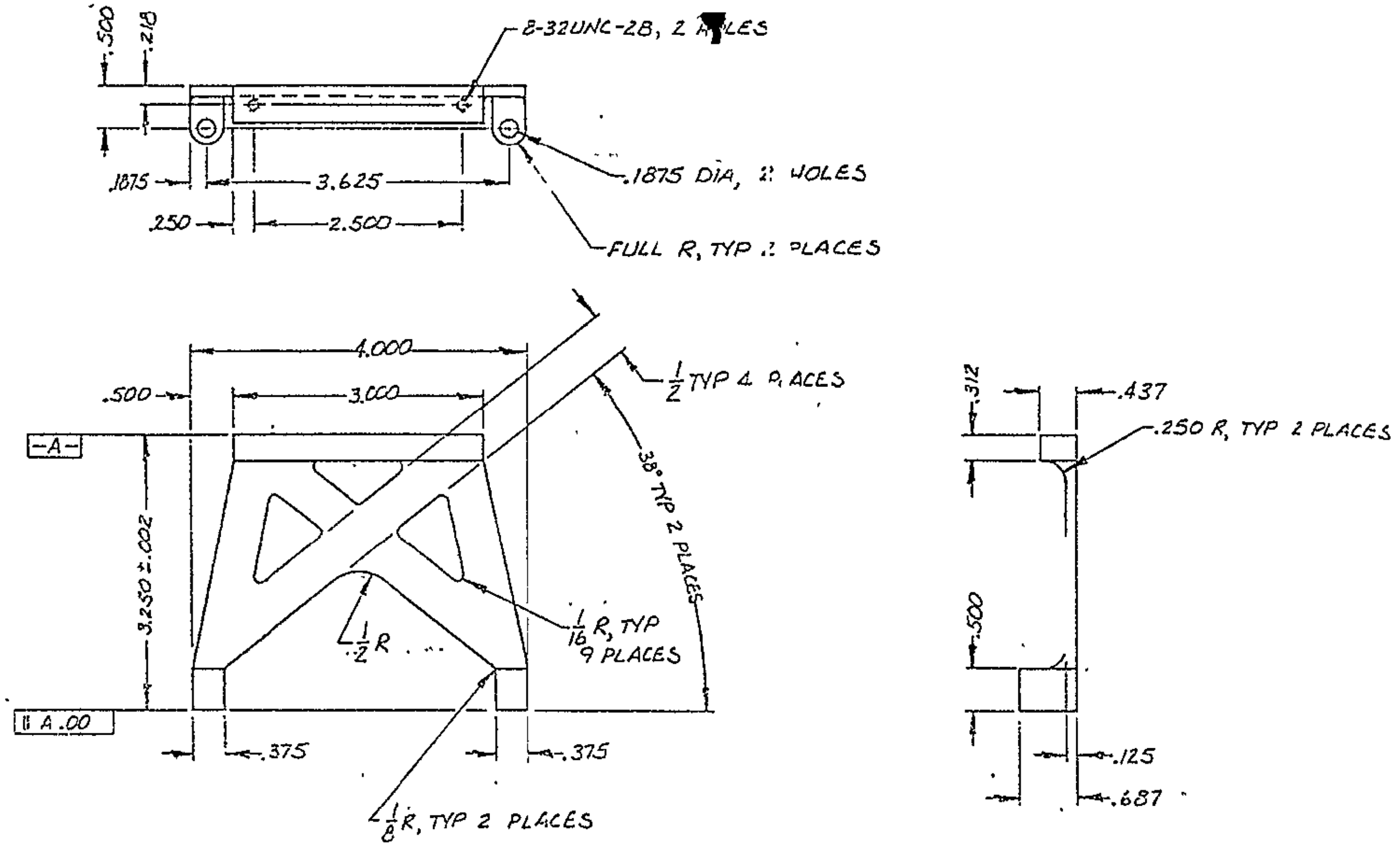
SIZE: C | CODE IDENT NO: 13499 | DWG NO: 044-0052-277

SCALE: NONE | WT | SHEET

141

NOTES: 1. FINISH: MIL-C-5541 CLASS 3 CHROMATE DIP

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
C			



QTY REQD	SYM	ITEM NO	COLLINS PART NO.	PART OR IDENTIFYING NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	CODE IDENT

LIST OF MATERIAL OR PARTS LIST

MATERIAL: 6061-T6 ALUM

APPLIED FINISH: SEE NOTE 1

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
DECIMAL DIM ± .008
FRACTIONAL DIM ± 1/64
DECIMAL HOLE DIA ± .005
MACHINED ANGLES ± 0 1
SHEARED ANGLES ± 0 25
FORMED ANGLES ± 1 0
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL—D—70327

CONTRACT NO.

	NAME	DATE
DR	[illegible]	[illegible]
CHK		
APPD		

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

SWITCH BRACKET NO. 2

SIZE	CODE IDENT NO.	DWG NO
C	13499	044-0052-277

SCALE NONE WT SHEET 18

1/